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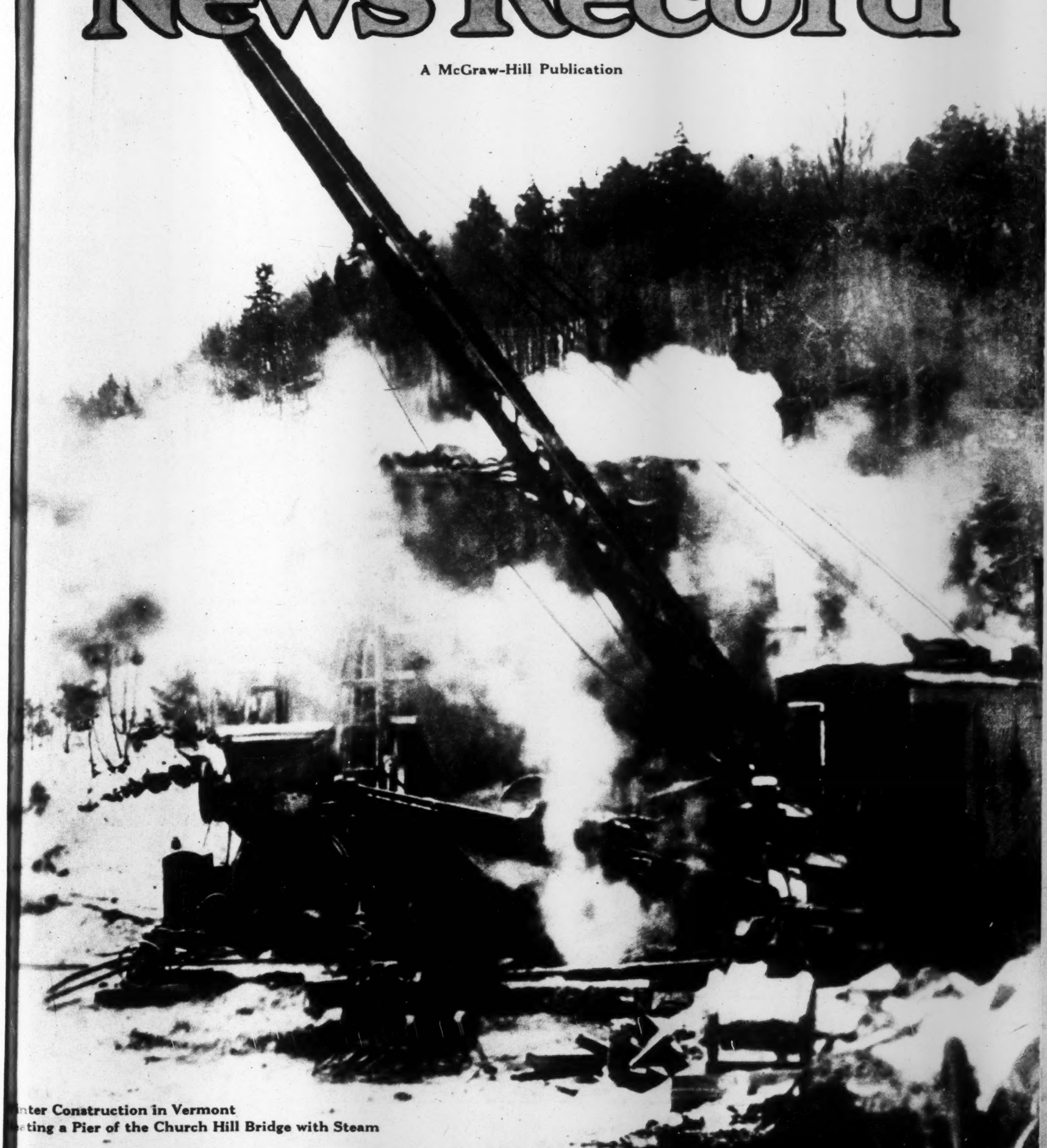

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DEVOTED TO CIVIL ENGINEERING AND CONTRACTING

F. E. Schmitt, *Editor*

Volume 104 NEW YORK, JUNE 19, 1930 Number 25

A City Official Remarks

SAYS a city official, rather pointedly, in some comments on the question of asking competitive bids for engineering services to municipalities: "Consulting engineers can hardly expect commissions or councils to recognize the ethics of the profession when they are willing to secure contracts on a competitive basis after advertisement." Here is an implied charge against engineers that can hardly be refuted successfully. Advertising for engineering services would die out very quickly if engineers of standing refrained from bidding. To this extent the primary blame for existence of such practices as we recently discussed in connection with the Lima bidding rests on engineers themselves. They support and therefore encourage the practice. More, they probably gave rise to it, through over-active solicitation of engagements. If, then, engineers are responsible for the conditions in question, they are equally the ones who bear the responsibility of abolishing them. But in this effort they are entitled to full support from the best element in municipal government circles. These latter face the question we propounded in our discussion two weeks ago (p. 882, May 29), namely: Is advertising and bidding for engineering counsel in the public interest? The answer, we hold, is an emphatic negative. Unless this view is unsound, every municipal man who indulges in the competitive-bid plan of engaging engineering counsel is recreant to his trust and defrauds the public which he serves.

More Bad Competition

A REMOTE parallel to the engineering-bid evil has long troubled contracting: what is known as shopping for bids. It is done by owners and architects in dealing with contractors, and by contractors themselves in dealing with subcontractors. One typical case is that in which a general contractor, having obtained a contract on the basis of bids by various subcontractors, proceeds to beat down these bids in progressive stages by various devices, including that of telling the low bidder that another made a lower figure but that he could obtain the work by bettering or matching this fictitious low. Identically similar practices are current among purchasing agents for industrial equipment and supplies; but regardless of this broader range of the evil, it is a besetting vice of certain circles of contracting, and this industry is at present fighting hard to eradicate it. The fight is gaining supporters steadily. An even more encouraging indication of possible reform is that each new building group is attaching itself to the cause in the conviction that cure lies with the seller and not with the buyer of building service. This is the announced conclusion of the Philadelphia Building Congress, which recently studied the problem. Heretofore the general contractor, as a buyer from material man and subcontractor, has been the chief obstacle to improvement. But he is also a seller—to the owner. Agreement on fair trade practices can therefore be worked out jointly by contractors, subcontractors and dealers; in other words, the contracting business must espouse and enforce fairness in the relations of its component groups. There is hope that this may come about in the organization of the allied industries committee of the Associated General Contractors and twelve specialized contractors' associations. Much progress has already been made, and actions like that of the Philadelphia Building Congress are constantly accelerating the movement.

Frost and Highways

THE article in this issue on frost damages and their remedy focuses attention on the relation of subgrade soil characteristics to frost action on road surfaces. There is no attempt to present intricacies of ground-freezing phenomena as they are being disclosed by research. Instead, bold generalization is presented. Obviously this offers dangers, but its purpose is wise. Soil technologists have so masked their exposition of soil engineering with exceptions and qualifications that to the practicing roadbuilder it is remote from his daily uses. This is not the fact with respect at least to frost action. The broad phenomena of ground freezing are simple. Only soils of high capillarity like silts and open-structure clays are particularly hazardous highway subgrade soils because of frost action. Their identification followed by their replacements by other materials or thorough drainage removes the hazard. Identification has been simplified by the research work of the Bureau of Public Roads. Soil surveys and determination are within the means, both technical and financial, of highway departments. The remedies are not always simple, but all of them are available, subject to engineering determination of relative practicability for specific cases. The roadbuilder's problem of frost action is at present largely economic. His objectives are to preserve investment in road structure and profit from road service. He may find it most economical to do this by strengthening the road surface to resist frost action or by subgrade construction and structures to eliminate frost action. He may even be justified often in letting frost have its way and then repairing the damage. In brief, soil engineering has put the problem of frost action in the same category with other problems of road construction and structures it can be solved wherever the solution is worth its cost.

Winter Concreting Lessons

FACILITATING winter construction by use of high-early-strength cement was done most successfully in several recent instances. That described in this issue, dealing with winter construction of bridges for the Vermont state highway department, will shortly be supplemented by an account of bridge work on the new Ohio River Boulevard of Allegheny County (Pittsburgh), equally instructive in character. The Vermont operations afford some practical comparisons of methods. In heating materials and protecting the placed concrete they generally followed familiar practice, except in the use of insulation to protect the top surfaces of bridge floors. Considering the climate and the exposure, dependence on an insulating covering alone to keep the frost from the concrete was a bold decision; its success is well worth noting by winter constructors. The use of high-early-strength cement in this work was more general than is ordinarily the practice where several operations by different contractors are being carried on. It was not difficult under the procedure followed to obtain, with this cement, a strength of 2,000 lb. in 48 to 72 hours. An important auxiliary disclosure of the tests was that the same strengths could be secured in the same time at no greater cost by using ordinary portland cement, though this expedient was not used in the field.' The process required merely that the richness of the mix should be increased by the quantity of standard portland which equaled in cost the extra cost of the high-early-strength cement for the specified mix. Altogether the conclusions drawn from the winter concreting operations of the Vermont highway engineers are of value.

Making the Most of Power

OPERATED alone, a water-power plant has certain inherent disadvantages. Except for the storage available in its own pond it must depend upon the run of the river, using what it can and wasting what of the water it cannot economically use. The rate and time of the daily flow depend upon the mills and power plants above, if there be such other plants, and the seasonal flow upon the vagaries of Nature. One plant, or even two or three plants, seldom can afford to pay the cost of providing headwater storage. But where, either through common ownership or mutual agreement, a whole group of plants along a river can be co-ordinated in their operation the situation is quite different. Under such circumstances the irregularities of Nature's supply of water can be evened out by headwater storage in the cost of which all the plants share, the operation of adjoining plants can be so interrelated that spillage over the dam at any one plant due to an increase in flow from the plant above can be avoided, and finally loads can be shifted from one plant to another to take advantage of local conditions such as a heavy runoff from a tributary stream. The development of the Catawba River in the Carolinas, described elsewhere in this issue, is a good example of what may be accomplished through such unified control. Considered alone, many of the power sites on the river are not attractive because of the flashy character of the river's flow before regulation; but when taken as a group supplied by a large reserve of stored water, the power sites become a valuable adjunct to the surrounding region. What has been accomplished there is a forceful reminder of the need for broad planning in the development of our rivers. A power site may rarely be considered alone, but should be studied as one of a series of power sites from which at no distant date maximum efficiency will be demanded.

International Deliberations

WE ARE in a period when international congresses are more or less epidemic—for natural reasons. Every country has its own difficulties in a given field of practice, while elsewhere the same difficulties either do not exist or are different in form; this invites comparison and joint discussion, so that one country may learn from another's experience how to adjust its troubles more effectively. Hence the popularity of international congresses. Their results, however, are frequently unsubstantial. At the recent international congress of building and public works, whose general discussions we reported last week, specific conclusions could not be reached on important matters. A representative instance was the subject of contract conditions, in which, after differences in national requirements has been brought out, it was found to be impossible to formulate a general finding. Certain delegates wanted a bill of quantities included in the contract, while others opposed this; differences arose over arbitration as against the engineer's or architect's final decision. Perhaps such divergences of view, arising from variation in existing customs, can in time be harmonized—though at so large a cost of time and trouble as to leave the net value of the ultimate result open to question. On another subject, that of public credits for house construction, the divergences were greater; the prospect of suiting national ways to an international compromise procedure seems remote, and possibly any compromise would be harmful rather than helpful, since no country has yet solved the problem of housing credits—rent limitation laws and public loans appear to have made matters worse if anything. Such difficulties have emerged in equal clearness from the doings of numerous other international technical or industrial congresses, tending to characterize them as failures. But on the other side their social and educational effect is large enough to weigh up part of this failure. Is it sufficient to repay their cost?

Typhoid and Water Supply

DURING many years the provision of safer water supplies was clearly entitled to chief credit for lessened typhoid deaths in our cities. As the curve fell it became increasingly difficult to say whether purer water had much to do with the decline. In recent years the *Journal* of the American Medical Association, ir its annual typhoid survey of American cities of 100,000 and over, has placed less and less weight, and latterly no weight at all, upon public water supplies as the cause of the typhoid it reports. This is no proof that some of the relatively few typhoid deaths still reported are not due to polluted water, although it may be assumed that the percentage is small.

A protest against talking of "vanishing typhoid" and an assertion that health officials are letting down in efforts to safeguard public water supplies from infection were features of a paper by Abel Wolman and A. E. Gorman, presented at the St. Louis convention of the American Water Works Association two weeks ago. To back their protest and assertion they submitted the results thus far obtained in a survey of outbreaks of water-borne diseases in the United States and Canada. An imposing number of such outbreaks shown by reports already in hand was presented. Some of them were of institutional rather than of public water supplies, and some were confined to sudden intestinal disturbances other than typhoid fever, but these facts should not lessen the concern of those in charge of public water supplies, because what happens on one may happen on the other.

Although outbreaks of water-borne diseases are still too frequent, and their elimination should be the goal, unquestionably they are being reduced both in number and in their toll of sickness and death—just as is typhoid as a whole, regardless of how spread. In fact, it is the reduction of typhoid from various constantly persisting causes—such as water always instead of occasionally polluted, milk and other foods unprotected, contacts and carriers—that brought many of the recent outbreaks to the surface; this and far better vital statistics and epidemiological work than was practiced in earlier years.

When a city had a typhoid death rate of 20 to 60 year after year, an explosive outbreak now and then was submerged, while with a low normal rate prevailing year after year a score of new cases in a small city and a hundred in one of even fair size not only creates local commotion but also brings in the state if not the federal health authorities.

If it were feasible for Messrs. Wolman and Gorman, with the aid of the various state sanitary engineers, to carry their survey of water-borne disease outbreaks back over three or four decades, a rapid decline in number, cases and deaths would undoubtedly be shown, perhaps more rapid than the decline in typhoid from all causes. Such a showing would not justify a let-up in precautionary methods. Rather it should stimulate an increase to the end that typhoid, epidemic and endemic, should be completely banished.

Progress toward this ideal is shown by the annual typhoid survey already mentioned. In the past two decades, prior to which typhoid had already been heavily reduced, the 74 largest cities of the country have cut their combined average annual typhoid rate from 20.58 to 1.56 per 100,000, or in ratio better than 16 to 1. For 1929, with seven cities additional (not previously in the 100,000 class, or else lacking figures for some of the earlier years), 81 cities had an average rate of 1.62. This was a trifle higher than the rate for the 74 cities but was lower than for those cities in 1928. Five of the cities had no typhoid deaths and in 1929 28 others had rates of from 0.3 to 1 per 100,000. At the other extreme there were only six cities out of 81 with rates above 5 and only one above 10, while in 1910 nearly every city (72 of 74) had rates of 10 and over. There were more cities with no typhoid deaths in 1928 and in 1927 than in 1929, and the no-death cities changed from year to year. While this shows that no city has conquered typhoid, it should be remembered that the cities under consideration have populations of 100,000 or more, so that no deaths whatever from typhoid is a remarkable record, even though it is not repeated the next year.

Although the cities considered are all large, there is reason to believe that almost complete freedom from water-borne typhoid infection extends far down the population scale. It is doubtless true that the chance of water-borne typhoid rises with diminishing population. Small places are apt to have less competent health administration, and usually do not enjoy the benefits of equally able design and operation of water-works as do larger cities. These factors increase the risk of water pollution and of epidemic development of disease—but according to the survey of water-borne outbreaks of disease already mentioned, the smaller places suffered no more, relative numbers considered, than did the large ones.

Although in recent years improved water supplies have played less and less part in the typhoid decline, they were large factors for many years. Relaxation in filtration and chlorination today would be disastrous. An extension of both would reduce the already low average typhoid rate and would make heavy cuts in the water-borne disease outbreaks—a considerable percentage of which in the past ten years, Wolman and Gorman's report indicates, have occurred on untreated supplies.

Recognition of the liability of water suppliers for sickness and death from water-borne typhoid is becoming more common. Damages have repeatedly been awarded against cities and water companies in suits based on such conditions. The latest instance is the compromise of a suit for damages brought against a water company supplying a hamlet in Texas. One or two Canadian cities have recently paid similar damages. Olean, N. Y., had to float a large bond issue to pay typhoid claims. The only relatively large city that has been thus involved is Albany, N. Y.—now busily engaged in providing itself with an upland supply which will enable it to abandon the heavily polluted Hudson River.

Great and widespread as has been the reduction of typhoid, neither cities nor water companies can rest on their laurels. Eternal vigilance, competently directed, is still the price of water safety.

Better Water-Works Coverage

MORE completely each year the American Water Works Association serves its chosen field of activity and service. Every official and department in a water property should look to it for help and guidance in carrying on this most basic of public utilities. The comparative ease with which a bare six months' campaign augmented the membership by 15 per cent is an indication of the organization's intrinsic strength of appeal to its field.

Close examination of the work of the association at its recent St. Louis convention discloses notable broadening of its activities. Thus, the new division of finance and accounting fills a gap in the field of water-works activities. It is taking up finance, general accounting, taxation, office management, purchases and supplies, personnel, public relations and legislation. Each of these subjects is to be studied separately with a view to defining, classifying and indicating methods of procedure; ultimately the material so developed may be published as standard practice. This division is the third research body set up to handle specific fields, the two others relating to general questions of plant operation and maintenance, and to the many special questions that arise in connection with water-purification plants.

An example of another entirely different activity which undoubtedly has aided in getting new members is the work on the economic condition of the personnel of the water industry. It is believed that these investigations will be exceedingly useful in securing and retaining effective personnel in those communities that appreciate the importance of their water-supply systems and insist upon efficient operation. Continuous tenure of office, freedom from political influence and promotion for merit are in every service conducive to efficiency in personnel; and in the field of water, even more than in others, this means definite profit for the public. Such work is almost unknown among technical organizations, though badly needed to protect and further the welfare of the individual member. The Water Works Association has greatly strengthened its appeal to the men in its field by entering courageously upon this enterprise.

These are only a few instances of the recent new and more complete coverage of its field by the American Water Works Association. With expanding constructive activity, and with a membership that will soon reach 3,000, the association has new promise of usefulness, and therewith still further opportunity to grow, until it covers completely the field of municipal service.

Thin Bridge Floors Concreted in Vermont Winter

Nine-Inch Slabs Housed Underneath and Insulated on Top—Instructive Comparison Made of High-Early-Strength and Standard Cement Concrete—Increased Winter Cost 10 to 15 Per Cent

By Harold L. Tilton and F. B. Saunders
Division Engineer and Resident Engineer,
Vermont Department of Highways, Montpelier, Vt.

A Notable Record of concreting thin slabs for bridge floors under conditions of severe cold and exposure is given in this article. Outstanding in the record are two conclusions: First, insulation of the slab top, and inclosure and heating underneath, are ample safeguards against frost, and second, standard cement of a volume equivalent in cost to the cost of the high-early-strength cement used will give concrete equally strong at early ages. A third statement of definite value is that the cost of the winter-placed concrete is from 10 to 15 per cent additional. As an example of carefully guarded cold-weather concreting, the bridge work of the Vermont highway department is a credit to its engineers. Their experience helps to make winter construction a more secure practice. —Editor.

After the great flood of Nov. 4, 1927, the Vermont department of highways was confronted with the task of replacing more than 1,200 bridges, 651 of which were greater than 20-ft. span. Temporary bridges were first hastily thrown across the streams to restore communication, which was completely at a standstill, and to enable food and relief supplies to be carried to the striken areas. The highway department was then expanded fourfold and work was rushed on the permanent replacement program. This work has taken two years.

With the arrival of winter in 1928 there were a number of the larger bridges only partly completed and the temporary bridges were in such locations and of such character that it was certain they would be swept away with the breaking up of the ice. It was imperative that the new bridges be opened to traffic before spring and therefore necessary for the concrete work to be carried on throughout a Vermont winter. This article describes the methods used to control the field work and the tests that were made under field conditions so that the results being obtained might be known at every stage of progress.

General Statement of Experience

We found that it is not particularly difficult to obtain, in the dead of a Vermont winter, concrete that is just as good as that which is placed in midsummer, provided the men in charge start out with the purpose of thoroughly heating the materials and protecting the fresh concrete from freezing. Halfway measures will inevitably result in frozen concrete. Thorough protection is not difficult or expensive. The problem consisted, first, in satisfactorily heating the materials; second, in inclosing and heating the fresh concrete until it had attained the required strength, and third, in making tests that would enable the results being obtained to be known at any time in the progress of the work and also over a long period of time.

CONCRETING FLOOR OF WATER ST. BRIDGE AT BETHEL, VT.

Concreting and Protecting Piers

The successful placing of concrete in piers and abutments was comparatively simple. A 2 per cent solution of calcium chloride was incorporated into the regular $1:2\frac{1}{2}:5$ mix. Heating the materials was best accomplished by steam. In one case this was furnished by a steam shovel which had been used for the excavation; in another case, where only gasoline-driven machinery had been used, a small boiler was set up. A steam jet was used in the water tank and a steam pipe grid under the sand and stone piles; it was necessary to heat all the materials in order to produce proper results. In addition, a kerosene flame heater was used in the mixer. In order that a prompt start in concreting might be made in the morning it was found advisable to start heating the stockpiles the day and night previous. By these methods the temperature of the concrete as it was discharged from the mixer was 75 deg. or higher.

The most satisfactory and simplest method of protecting the freshly placed concrete in piers was to hang canvas over the top and down the sides outside the studding and to

INTERIOR OF HOUSING, WATER ST. BRIDGE, BETHEL, VT.

insert between the canvas and the forms several outlets of live steam. It was possible to maintain a temperature of 50 deg. under the canvas even in severe weather. The heat was removed after 48 hours. Even as late as ten days after placing, the surface of the concrete was still warm when the forms were removed.

Floor Protection More Difficult

It required more care properly to protect and cure the floor slabs, which were 9 in. thick, and the sidewalk slabs, which were 5 in. thick. A 1 : 2 : 4 concrete was specified. The specifications also required that the slab be inclosed and heated for fourteen days. To expedite the opening of the bridges and to lessen the expense of heating, the contractors were allowed to use an approved high-early-strength cement. The materials were heated in the manner previously described.

Floorslabs were protected by building an inclosure of canvas or fiber-craft paper below. Coke-burning salamanders supplied the heat. About 125 sq.ft. of floor area was allowed per salamander, with extra salamanders near the walls on windy days. It was originally intended to leave an air space around the edges of the slab and to support a hay-covered canvas top about a foot above the floor surface, thus allowing the warm air from the inclosure below to circulate above the slab as well as underneath. It was found difficult by this arrangement to maintain a satisfactory temperature above the slab, and the heat was not uniformly distributed on windy days.

The use of live steam instead of salamanders was soon abandoned. The heat was not so uniformly distributed as the salamander heat, particularly on windy days. As hydration in the concrete was less rapid than with salamander heat, the concrete was much more susceptible to frost penetration after the heating was discontinued. Furthermore, salamanders have no joints or valves to freeze if the pressure drops, nor flues that require cleaning. An outside temperature of 20 deg. below zero is conducive to proper activity on the part of the workmen tending the salamanders underneath the slab in order that their personal comfort may be assured.

On Twin Bridge, in Middlesex, Vt., H. P. Radigan, resident engineer, developed a much superior method of protection for the surface of the slab, which was immediately adopted on all other jobs. The salamander heat was confined entirely to the inclosure beneath the slab. As soon as the concrete was screeded, building paper was laid on it. When the surface was ready for brooming, the paper was removed. As the brooming was completed it was replaced. Then a covering of hay was spread on the paper and battened down with boards. By applying the paper directly to the concrete surface the heat was retained in the concrete uniformly all over the surface.

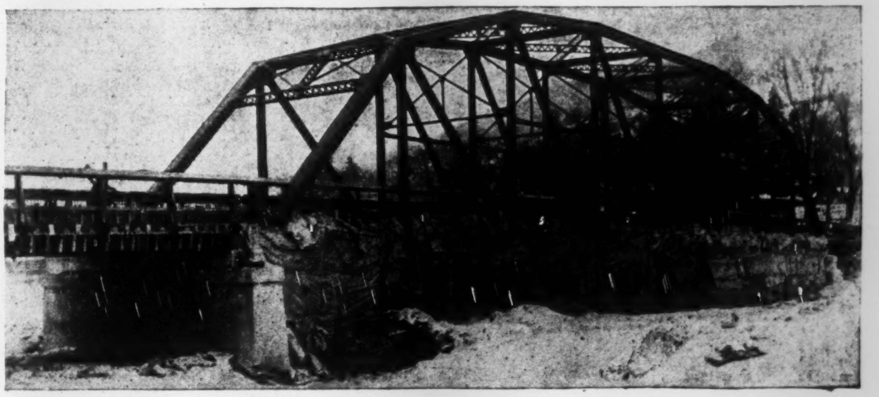
This method, of heating by salamanders underneath and of applying paper and hay directly on the surface, worked out very satisfactorily. It is interesting to note that during the first 24 hours the temperature underneath the paper on top of the slab was from 2 to 3 deg. higher than that in the heated inclosure underneath the slab. The writer has repeatedly in zero weather inserted a thermometer under the paper on the surface of the slab and found the temperature to be 70 deg.

Testing for Concrete Control

Test beams 6x6x36 in. were made from the concrete that was being placed in the slab. These were laid on the slab and cured under identical conditions. It was the intention to cease heating the inclosed structure when the modulus of rupture of the broken test beams indicated a compressive strength of 2,000 lb. per sq.in. In mild winter weather this strength was developed in 48 hours, and even in severe weather it was developed in 72 hours.

It was observed, however, that at this early age there was still so much moisture in the concrete that the frost would completely penetrate a test beam within five or six hours after it was exposed to the outside atmospheric temperature. Therefore, in order to avoid any possible injurious effects of the frost action, it was deemed advisable not to expose the thin floorslabs too soon to severe temperatures and to continue the heat in the inclosure for an additional 24 hours after the 2,000-lb. concrete had been developed in the beams.

When the heating of the structure was discontinued, the beams were laid outdoors beside the bridge and subjected to the same winter temperatures as the bridge slab. When the time for breaking arrived, they were placed indoors a few hours to thaw the frost out before



UNDERSLAB HOUSING, FLOOR TO ICE, WATER ST. BRIDGE, BETHEL, VT.

breaking them. It was early discovered that a beam which has attained a 2,000-lb. strength before the heat has been removed and then become permeated with frost upon later exposure to winter temperatures will show an apparent strength of more than twice its real strength if it is broken while still permeated with frost.

A factor of 5.25 was used as expressing the relation between modulus of rupture and compressive strength, which is generally considered conservative. The results of these beam tests are a quite conservative measure of the actual strength of the concrete in the structure, because of the fact that the beams, being so much smaller than the floorslab on which they rested and having so much larger ratio of surface to volume, could not retain their heat as well as could the slab. When the temperature of the slab was 70 deg., that of the beam would be 50 deg. We therefore feel justified in considering that the strength of the concrete in the structure was at all times considerably greater than that indicated by the test beams.

The amount of water used was approximately 6½ gal. per bag of cement. The moisture contents of the stockpiles varied greatly from day to day and even from hour to hour, and considerable judgment was required in mixing. There was no attempt to specify an arbitrary amount of water to be used, the policy being to use the smallest amount of water that would produce a concrete that could be worked properly around the reinforcing.

Comparative Tests With High-Early-Strength and Standard Cement

Two brands of high-early-strength cement were used, with results that are practically identical. Additional tests were made with the object of determining the early strength of a concrete containing an amount of standard cement equivalent in cost to that of the high-early-strength cement used per cubic yard of concrete.

Table I represents the results of the tests made on the floorslab of Twin Bridge, a $65,000 structure in Middlesex. The H. L. Hauser Building Co. was the contractor. A 1:2:4 concrete was used, containing six bags per cubic yard of an approved early-high-strength cement. This slab was placed from Dec. 11 to Dec. 15, 1928. The atmospheric temperatures were quite favorable for this time of year, ranging from 20 deg. to 38 deg. during working hours. A steam line and return was used in the inclosure beneath the slab, in addition to salamanders. In 42 hours the concrete had attained a compressive strength of 2,300 lb. per sq.in. and in 28 days 4,000 lb. per sq.in. The coarse aggregate was crushed granite.

TABLE I—BEAM TESTS, TWIN BRIDGE, MIDDLESEX, VT.

Mix, 1:2:4; high-early-strength cement; coarse aggregate—crushed granite; 2 per cent calcium chloride

Date 1928	Air Temp., Deg.	Concrete Temp. as Placed, Deg.	Temp. Top of Slab, Deg.	Temp. Below Slab Deg.
Dec. 11, 3 p.m.	34	78	..	85
Dec. 12, 10 a.m.	34	90	74	89
Dec. 13, 8 a.m.	20	..	70	73
Dec. 13, 11 a.m.	28	84	62	62
Dec. 13, 3 p.m.	31	84	65	68
Dec. 14, 10 a.m.	38	72	67	70
Dec. 15, 12 noon	36	82	78	88
Dec. 16, 11 a.m.	32	..	78	..
Dec. 16, 3 p.m.	32	..	74	..
Dec. 17, 7:30 a.m.	36	..	72	..
Dec. 17, 11 a.m.	38	..	71	..
Dec. 17, 4 p.m.	38	..	71	..

Beam tests: Results of fourteen beams (28 breaks)

	Lb. Per Sq.In.		Lb. Per Sq.In.
18 hours	900	72 hours	2,783
24 hours	1,843	7 days	3,260
42 hours	2,339	28 days	4,010
48 hours	2,504	60 days	4,040

TABLE II—BEAM TESTS, BROOKFIELD BRIDGE

Concrete T-beam bridge, 30-ft. span; slab and beams placed Jan. 18 and 19, 1928; atmospheric temperatures varied from 6 to 40 deg. on these dates; atmospheric temperatures averaged 32 deg. while placing concrete; average temperatures on top of slab 75 deg.; average temperatures beneath slab 74 deg.; average temperatures of concrete when deposited 75 deg.; curing heat discontinued in 72 hours; mix 1:2:4; coarse aggregate gravel.

Average of 27 beams (54 breaks)

Time	High Early Strength (6 Bags Per Cu.Yd.), Lb. Per Sq.In.	Standard (9.6 Bags Per Cu.Yd.), Lb. Per Sq.In.	Standard (6 Bags Per Cu.Yd.), Lb. Per Sq.In.
24 hours	1,958	1,795	.....
48 hour	2,125	2,060	.....
96 hours	2,228	2,452	1,765
18 days	2,554	2,203	1,813
30 days	2,557	2,757	2,304

Table II shows the results of tests on a small T-beam bridge in Brookfield, Vt. Hayward & Noble were the contractors. The floor was placed on Jan. 18 and 19, 1928. Weather conditions were quite favorable, the temperature being about 32 deg. while placing concrete. In this case, 9.6 bags of standard cement were equivalent in cost to six bags of high-early-strength cement. As the work progressed batches containing 9.6 bags of standard cement per cubic yard of concrete were mixed

TABLE III—BEAM TESTS, WATER ST. AND OVERPASS BRIDGES, BETHEL, VT.

Results of 238 beams, (476 breaks). 2 per cent calcium chloride used

1928 Date Placed	Cement	Atmosphere Minimum Temperature for Day, Deg	Atmosphere Average Temperature for Day, Deg	Average Temperature for Slab While Curing, Deg	Average Temperature Below Slab While Curing, Deg.	Period of Heating, Hr	Compressive Strength, Lb. Per Sq.In. 48 Hr.	96 Hr.	7 Days	14 Days	28 Days	5 Mo.
Jan 9-10	H. E. S.	12	20	69	85	72	.....	.....	.....	.....	2,803	.....
Jan 12	H. E. S.	14	19	65	78	48	1,723	.....	.....	2,278	2,814	.....
Jan. 12	H. E. S.	14	19	65	78	96	.....	.....	.....	.....	.....	.....
Jan 26	Standard	6	13	65	74	72	.....	2,116	2,535	2,609	2,656	3,754
Jan 26	H. E. S.	6	13	65	74	96	.....	2,032	2,294	2,578	2,664	3,129
Jan 31	Standard	10	12	80	92	120	1,921	2,252	2,331	2,504	2,866	3,250
Feb. 15	Standard	10	27	78	84	72	1,805	2,473	2,404	.....	3,071	3,801
Feb. 17	H. E. S.	20	27	89	92	96	.....	2,132	2,391	2,825	.....	3,328
Feb. 19	H. E. S.	22	24	64	71	96	.....	2,320	.....	2,931	2,636	3,166
Feb. 19	H. E. S.	22	24	64	71	96	.....	.....	2,226	2,609	2,583	3,391
Feb. 27	H. E. S.	32	39	77	87	72	2,089	.....	.....	2,772	3,386	3,386
Feb. 27	Standard	32	39	77	87	72	1,963	2,431	2,551	.....	.....	3,234
Feb. 28	H. E. S.	22	41	68.5	81	72	1,811	2,714	2,483	.....	2,782	3,265
March 1	H. E. S.	32	33	80.5	82	96	1,706	2,394	2,378	.....	2,557	3,276
March 1	Standard	32	33	80.5	82	96	1,948	2,499	.....	.....	2,552	.....
March 2	H. E. S.	18	24	72	90	96	1,948	2,620	2,705	.....	2,866	3,024
March 7	H. E. S.	29	31	69	66	72	1,948	2,300	2,499	.....	2,336	3,073
March 13	Standard	35	38	74	93	84	1,963	2,446	2,336	.....	3,137	3,365
March 13	H. E. S.	35	38	74	93	84	2,084	2,252	2,404	.....	3,359	.....
March 15	H. E. S.	38	39	73.5	85	84	2,029	2,447	2,500	2,688	.....	3,229
March 15	Standard	38	39	73.5	85	84	1,979	2,499	2,635	.....	.....	.....
Average, high-early-strength cement (6 bags per cubic yard)							1,913	2,351	2,461	2,660	2,754	3,181
Average, standard cement (8.7 bags per cubic yard)							1,910	2,377	2,393	2,673	2,910	3,445

PLANT FOR WINTER CONCRETING A BRIDGE PIER

and test beams taken. A comparison of tests shows substantially the same strength at all times in concrete made with the high-early-strength cement and that made with an amount of standard cement equivalent in cost to that of the high-early-strength cement. In each case, 2,000-lb. concrete was developed in 48 hours. It is interesting to note that the beams made with six bags of standard cement per cubic yard required between 18 and 30 days to attain a strength of 2,000 lb. per sq.in. Curing heat was removed in 72 hours and the beams were subjected to extreme low temperatures thereafter.

Table III shows the results of tests on the Water St. bridge, a $100,000 structure, and the Overpass bridge, a $75,000 structure in Bethel, Vt. Charles I. Hosmer was the contractor. These floorslabs were placed and beams were tested during January, February and March, and both slabs and test beams were subjected to subzero temperatures as soon as the curing heat was removed. An approved high-early-strength cement was used on this job. Test beams were also made from concrete containing 8.7 bags of standard cement per cubic yard of concrete, which on this job was the equivalent in cost to six bags of the high-early-strength cement. Again it will be observed that there is substantially the same strength at all stages in both the high-early-strength cement concrete and the standard cement concrete.

In each case 1,900-lb. concrete was obtained in 48 hours and 2,300-lb. concrete in 96 hours. It is interesting to note that the concrete slowly but steadily gained in strength from 2,300 lb. at 96 hours to 2,600 lb. in fourteen days and 3,200 lb. in five months, in spite of the fact that after the curing heat was discontinued the concrete was subjected to winter temperatures as low as 26 deg. below zero.

Conclusions on Winter Concreting

Our experience in concreting during a Vermont winter and the results of the tests of the 294 beams have caused us to form the following conclusions:

1. It is not difficult to obtain first-class concrete, even in thin slabs, during severe winter weather, provided that the work of heating the materials and protecting and heating the freshly placed concrete is carried on with the intention of thoroughly taking the necessary precautions. Constant vigilance and conscientious supervision are essential.
2. From the contractor's viewpoint it is entirely practicable and will cost from 10 to 15 per cent additional depending on size, character and location of the work.
3. The use of high-early-strength cement, with proper heating of materials and a properly heated inclosure for curing, will produce 2,000-lb. concrete in from 48 to 72 hours in severe winter weather.
4. An increase of approximately 50 per cent in the amount of a standard cement will produce the same result under the same conditions as will the use of a high-early-strength cement.
5. A thin concrete floor slab will slowly and steadily gain in strength after it has once attained a strength of 2,000 lb. per sq.in., even though it is entirely permeated with frost from sub-zero weather after the heating of the structure has been discontinued.
6. The use of test beams is a sure way of knowing what is happening to the concrete at all periods.

The work and tests described in this article were carried out under the direction of H. E. Sargent, chief engineer of the Vermont Department of Highways, Montpelier, Vt.

Refuse Disposal at Bradford, England

Disposal of garbage and refuse by "controlled tipping" (fill and cover) has been practiced at Bradford, England, for a dozen years or so. The method came into use during the late war when the town found that it could not proceed with the construction of a projected additional incinerator at a cost of £100,000, or nearly $500,000. To meet the situation Ernest Call, superintendent of cleansing, began using refuse to fill waste land for parks, recreation grounds and other purposes. The working front of the "tip" or dump is kept about 24x6 ft. deep, and "the sides are covered with earth from excavations, ashes, sweepings, etc., as the 'tip' extends, so that at the end of each day's work no refuse can be seen." In commenting on this matter London *Municipal Engineering* says: "Numerous local authorities have copied the Bradford system, and if the London borough councils had adopted a similar system" when Bradford did, "the appalling nuisance of the London tips would not have developed to the extent they have."

More Automobile Storage in Chicago

Storage facilities for automobiles in the central business district of Chicago have increased 52 per cent since 1927. A survey by the traffic division of the bureau of streets discloses 105 establishments offering storage space, of which 64 are parking lots and 41 garage buildings. The increase in lots was 30 and garages 15. The present capacity is for 8,140 cars in lots and 12,041 in buildings. In 1927 the survey indicated that 11,240 cars were stored, whereas in 1930 the daily patrons were 16,362, an increase of 46 per cent, due, it is held, to the larger volume of passenger car traffic into the district. The 1929 count of vehicles showed an increase of 22 per cent entering the district as compared with 1926 before the no-parking ordinance went into effect.

Rapid-Hardening Cement Used in Patching Concrete Pavement

Patched Areas Opened in 24 Hours, Causing a Minimum Interference With Heavy Traffic on Narrow Highways

By D. S. MacBride

Vice-President, Lone Star Portland Cement Co., Philadelphia, Pa.

PENNSYLVANIA is meeting the problem of repairing old and narrow heavily traveled concrete roads under traffic by using high-early-strength cement. By using pneumatic drills to remove and trim up the broken areas, patches are made and opened to traffic in 24 to 30 hours.

A typical example of this work is found in the repairs made on the Lincoln Highway between Philadelphia and Morrisville, Pa. The major portion of this road, concrete slab 20 ft. wide and 6-8-6 in. thick, was constructed in 1921. The mix used was 1:2:3, reinforced with wire mesh weighing 42 lb. per 100 sq.ft. placed 2 in. below the surface. Because of a narrow right-of-way, drainage and subgrade conditions are only fair over several extended sections of the highway.

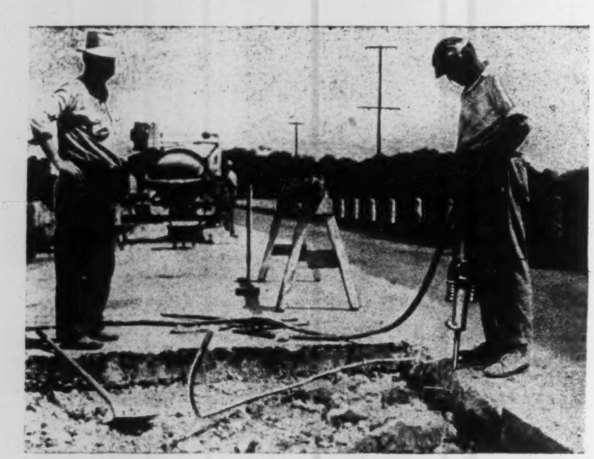


FIG. 1—PREPARING BREAKS FOR PATCHING WITH RAPID-HARDENING CEMENT, PENNSYLVANIA HIGHWAYS

A traffic count on this section showed a daily average volume of 13,648 vehicles, 7 per cent of which were heavy motor trucks, mostly traveling at night. Because of the curling up of the 20-ft. slab under night temperatures, tending to lift the edges off of the subgrade, this heavy truck traffic has had a destructive effect on the pavement's edges. Barricading patches seven to ten days was out of the question in view of the heavy traffic.

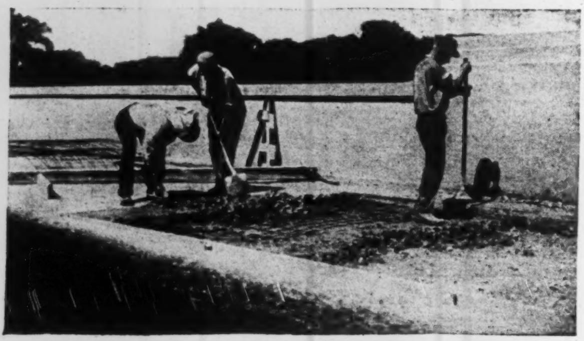


FIG. 2—PLACING CONCRETE IN A HIGHWAY PATCH

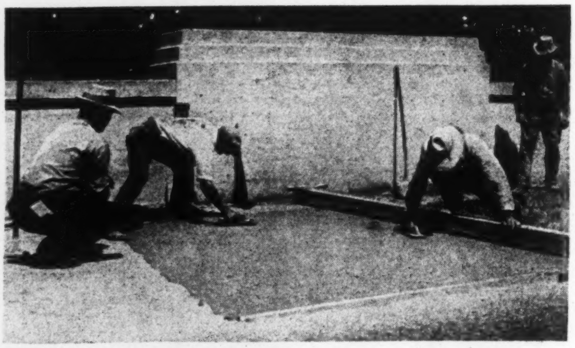


FIG. 3—FINISHING A PATCH WITH A HAND FLOAT

Concrete mixtures richer than normal in cement were tried with and without strength accelerators. But the method finally adopted as giving the best results is as follows: The broken area is removed and the opening is made rectangular in shape by pneumatic drills operated by a portable gasoline compressor, as shown in Fig. 1. The edges of the opening are trimmed so as to be straight and vertical and the side form is then set and the subgrade cleaned up.

Concrete is mixed in a portable one-sack mixer using a $1:1\frac{1}{2}:2\frac{1}{2}$ mix, the coarse aggregate being crushed limestone. Approximately 3 gal. of water per batch is used, giving a stiff mix well adapted to the tamping necessary for thorough consolidation. Furthermore, the low water content minimizes shrinkage, thus insuring a satisfactory bond between the new and the old work. Practically the same procedure is used in making the patches as is used on new road construction, except that, because of the stiffer mix, hand tamping is freely used. After the first course is placed and thoroughly tamped, wire-mesh reinforcing weighing 42 lb. per 100 sq.ft. is placed on the lower course and the final course is then placed and thoroughly rammed (Fig. 2). To insure a good riding surface the patch is screeded, using the side form and pavement as templets. Final finishing is accomplished with hand floats (Fig. 3).

Particular attention is paid to the curing of the pavement. Strips of saturated burlap are placed over the patch as soon as finished, and when hardening has sufficiently progressed a second layer is added. This is kept wet by frequent sprinkling until the patch is opened to traffic the following day.

Hydro-Electric Power in North Carolina

Figures issued by the division of water resources and engineering of the North Carolina department of conservation and development reveal that this state, in 1929, produced 6.9 per cent of the hydro-electric power generated in the United States, being surpassed only by California, with 16.7 per cent, and New York, with 13.1 per cent. Generating capacity of all power plants was increased during the year by 20 per cent, giving a total installation of 1,655,900 hp. Output from all electric plants in the state was 13.6 per cent greater than for 1928, exceeding 2,500,000,000 kw.-hr., of which 93 per cent was produced by water power. Construction is now under way on a 66,000-hp. hydro-electric plant, with a second plant of 56,000 hp. contemplated.

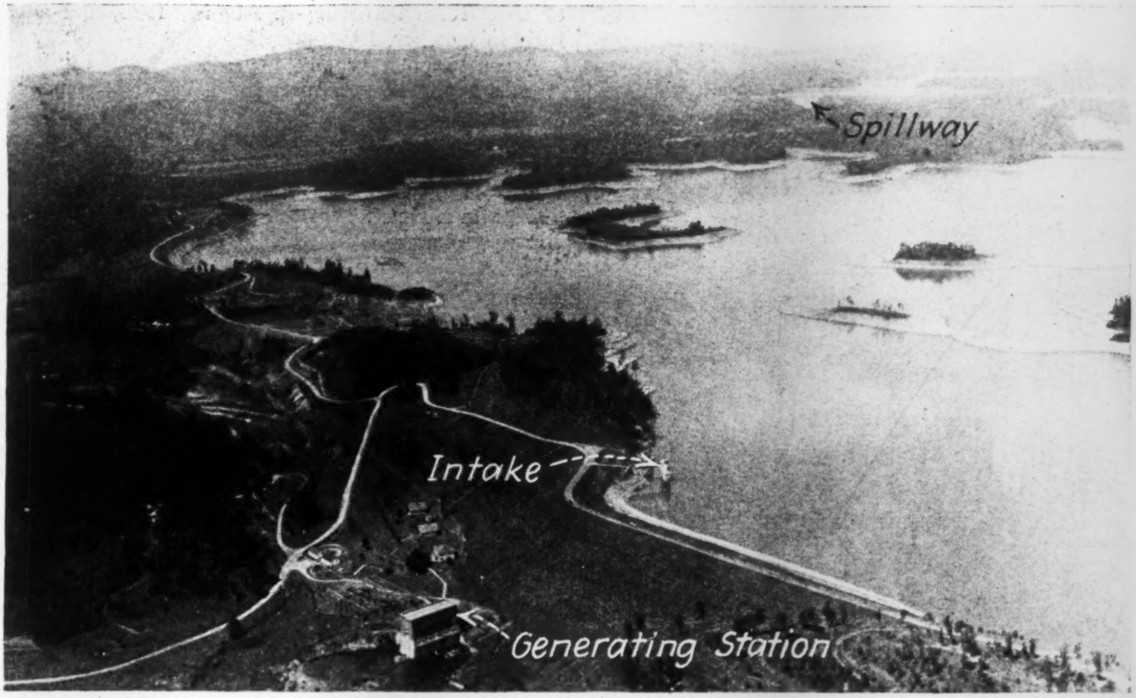


FIG. 1—STORAGE RESERVOIR FORMED BY EARTH DAM AT BRIDGEWATER STATION ON CATAWBA RIVER
Note the way in which natural lake conditions have been obtained by removing the trees and other vegetation along the shore line.

Power Possibilities of Catawba River Highly Developed Through Stream Control

Use of Large Storage Reservoirs and Unified Control of Power Plants Along the River Produces an Unusually Large Amount of Prime Power From a Flashy Stream

THE extent to which a river of flashy streamflow characteristics may be made to produce a large amount of prime electric power through the use of storage reservoirs and by co-ordinated control of water at the power plants is clearly shown by what has been done by the Duke Power Co. with the Catawba River in North and South Carolina. Storage is provided in reservoirs having a combined superficial area of more than 55,000 acres and a total useful storage approaching 42 billion cubic feet, of which 35.5 billion cu.ft. is available within the operating limits of the waterwheels in the power plants of the storage reservoirs.

At the present time the power company has generating equipment rated at a total capacity of 1,350,000 hp., with nearly 600,000 hp. furnished by water-power plants, of which all except 32,000 hp. is on the Catawba River. Until a few years ago the system depended mainly upon hydro-electric power generated on that river, but the company has now added some steam stations to its equipment, and these stations make it possible to take greater advantage of the available power in the river than could be taken heretofore.

Characteristics of the Catawba River—The Catawba River above the Wateree dam, the lowest of the ten dams of the Duke power system, has a drainage area of 5,000 square miles. The river rises on the east slope of the Blue Ridge Mountains, a range extending generally in a direction southwest to northeast and having peaks reaching 3,000 to 6,700 ft. above sea level. The southeasterly slopes upon which the Catawba River and its upper branches originate are comparatively abrupt, dropping in a distance of 15 to 20 miles from the summit heights mentioned down to an elevation of 1,200 ft. at the spillway of the upper reservoir of the system at Bridgewater, N. C. In the 210 miles between that reservoir and the Wateree plant the fall is about 1,050 ft., most of it occurring in such a way as to render its utilization for power purposes practicable. The greatest amount of storage is available in the Bridgewater reservoir at the upper end of the system, so that a large proportion of the total storage is used to advantage in all of the power stations of the system.

Watershed—The mountains in which the Catawba River heads are among the oldest on the earth. With few exceptions they have a deep soil covering underlying ledge rock of gneiss and granite that permits the passage of only a limited amount of the water percolating to them through the soil covering. In the foothill country and farther down the stream as the region flattens out into the Piedmont section of the Carolinas, there are similar soil and underlying-rock formations. Hence there is comparatively little loss of water through underground channels. In fact, the conditions are such that a considerable amount of underground water storage is provided.

The mountain and upper foothill sections of the watershed are densely timbered. Practically all of the area has been cut over, but in that latitude with the prevailing conditions of rainfall and atmospheric humidity, natural reforestation is fast. Consequently, as less than 5 per cent of the area is cleared, the present forest cover retains nearly as much flow as in the primeval forest.

Farther downstream the proportion of cleared and cultivated land is much higher. In some sections it reaches more than half the total area, but as the lower portions of the developed section of the river are reached. there is a gradual reduction of the cleared area until in the vicinity of the Wateree station the proportion is less than one-fifth.

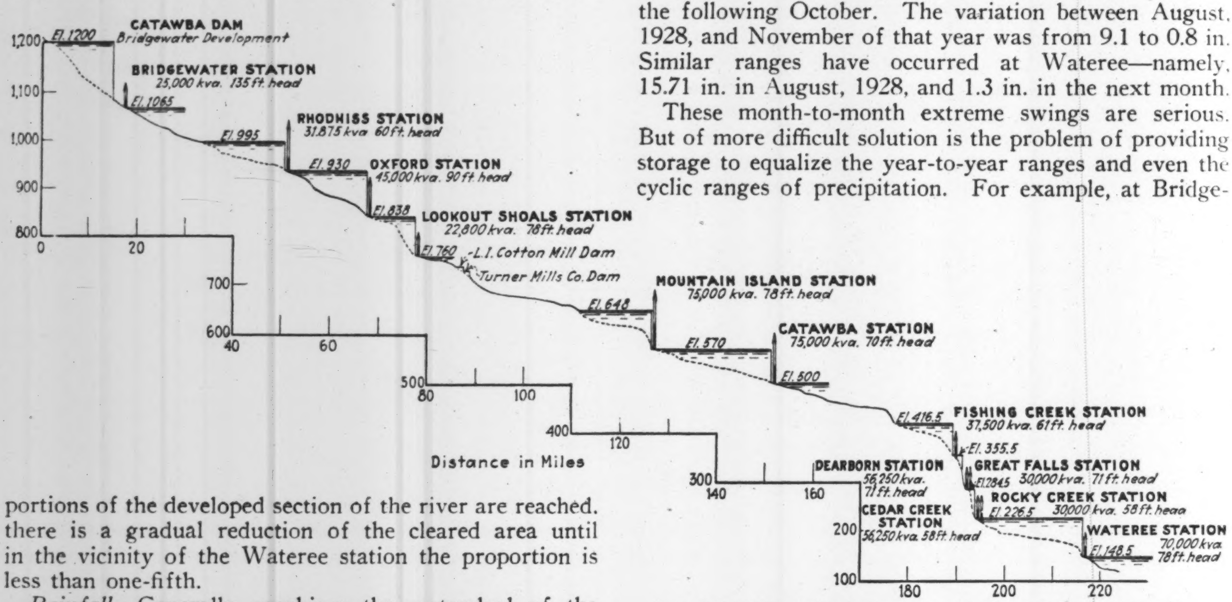

CATAWBA DAM
El. 1200
Bridgewater Development
BRIDGEWATER STATION
25,000 kva. 135 ft. head
El. 1065
RHODHISS STATION
31,875 kva 60 ft. head
El. 995
El. 930
OXFORD STATION
45,000 kva. 90 ft. head
El. 838
LOOKOUT SHOALS STATION
22,800 kva. 78 ft. head
El. 760
L. I. Cotton Mill Dam
Turner Mills Co. Dam
MOUNTAIN ISLAND STATION
75,000 kva. 78 ft. head
El. 648
El. 570
CATAWBA STATION
75,000 kva. 70 ft. head
El. 500
El. 416.5
FISHING CREEK STATION
37,500 kva. 61 ft. head
El. 355.5
DEARBORN STATION
56,250 kva.
71 ft. head
GREAT FALLS STATION
El. 284.5
30,000 kva. 71 ft. head
CEDAR CREEK STATION
56,250 kva. 58 ft. head
ROCKY CREEK STATION
El. 226.5
30,000 kva. 58 ft. head
WATEREE STATION
70,000 kva.
78 ft. head
El. 148.5
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
20
40
60
80
100
120
140
160
180
200
220
Distance in Miles

FIG. 2—PROFILE OF THE CATAWBA RIVER, SHOWING HYDRO-ELECTRIC DEVELOPMENTS

Rainfall—Generally speaking, the watershed of the Catawba River enjoys a large annual rainfall, but it is seriously lacking in uniformity of distribution, either through the year or from year to year. Average figures over a period of 30 to 40 years show a wide variation from the region around the Wateree station up to the crest of the mountains. The mean ranges from 45 in. per year at Wateree to more than 70 in. in small areas in the mountains. On most of the upper reaches of the watershed, however, the rainfall is in excess of 55 in. per year.

Taking the average of many years' records, the period of least rainfall is from mid-August to mid-November. But even this phase has no regularity, since in 1928 and 1929 that period was one of exceptionally heavy precipitation, with one of the greatest floods in the history of the stream occurring in August, 1928, and another early in October, 1929.

Accompanying graphs show the total rainfall by months for twelve years at the lower development, the Wateree station, and at the upper station at the Bridgewater reservoir. It is noteworthy that at Bridgewater a total of 13.35 in. in August, 1920, was followed by 0.3 in. the following October. The variation between August, 1928, and November of that year was from 9.1 to 0.8 in. Similar ranges have occurred at Wateree—namely, 15.71 in. in August, 1928, and 1.3 in. in the next month.

These month-to-month extreme swings are serious. But of more difficult solution is the problem of providing storage to equalize the year-to-year ranges and even the cyclic ranges of precipitation. For example, at Bridgewater in 1925 only 33 in. of rainfall was recorded, with but 43 in. the following year. In 1918 there was 62 in., and in 1919 more than 59 in. of precipitation at that station; in other words, a two-year total having a difference of nearly 60 per cent. Depletion of groundwater in long cycles of dry weather also is an important factor.

Temperature conditions range from sub-zero weather, occurring several times each winter in the higher altitudes, to a limited amount of freezing weather at the Wateree station. Ice never forms on the Wateree reservoir nor does the Catawba River ever carry floating ice at any of the power plants.

Streamflow—Under these climatic conditions there

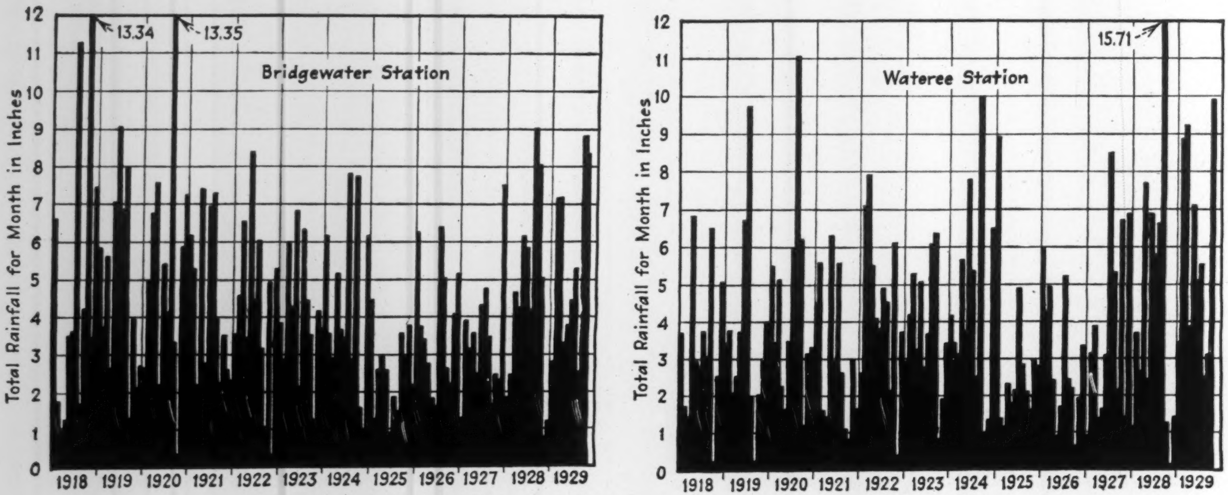


FIG. 3—RAINFALL RECORDS AT BRIDGEWATER AND WATEREE STATIONS

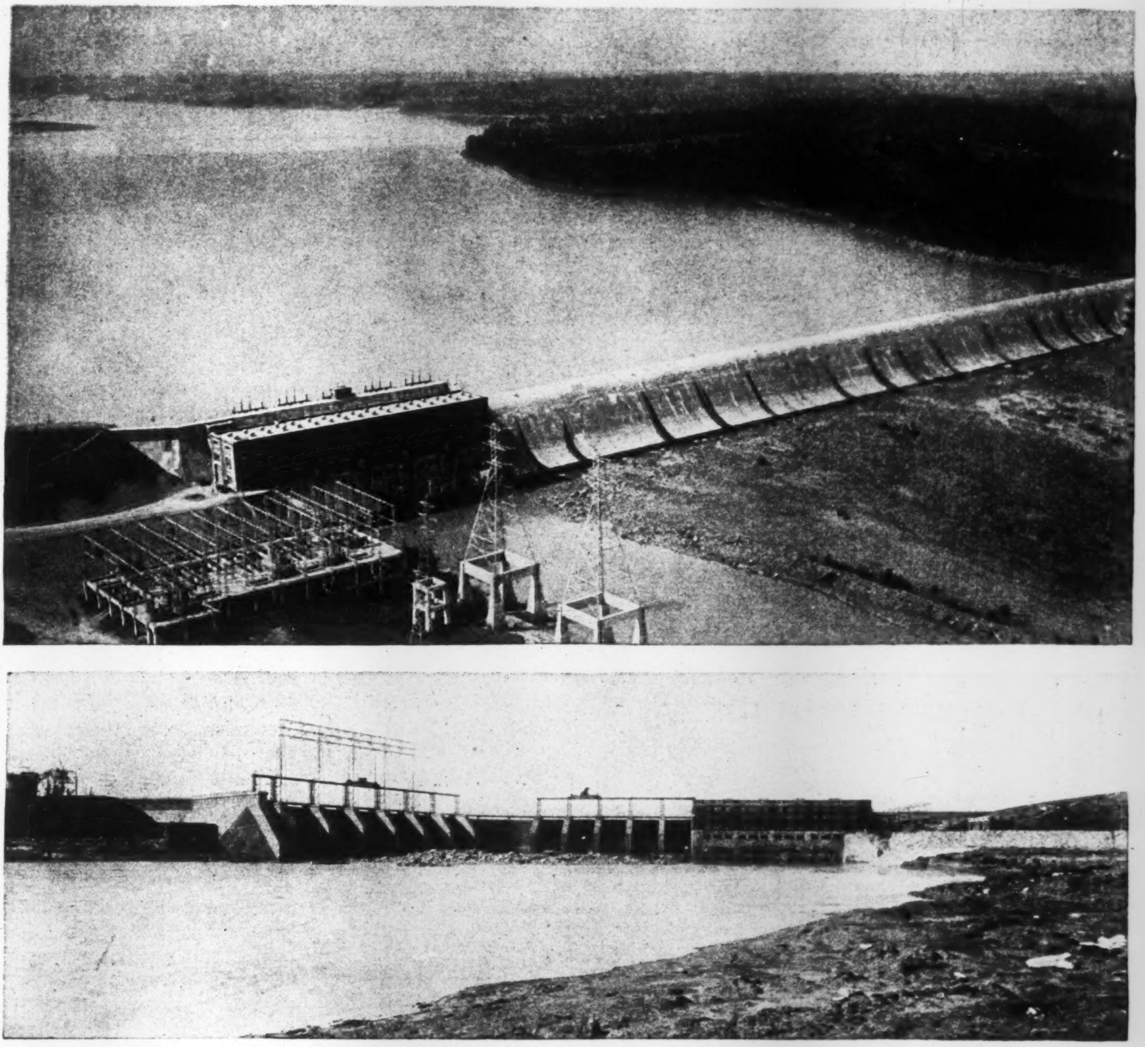


FIG. 4—CONTRASTING TYPES OF HYDRO-ELECTRIC STATIONS
Above: The Wateree station with a long overflow spillway. Below: The Catawba station with its pool entirely controlled by gates.

is a wide variation in the flow of the Catawba River. For example, the minimum flow of record of the three tributaries feeding the great storage reservoir at Bridgewater is estimated at 70.5 sec.-ft. This occurred during the latter part of 1925, in which year there was on the watershed the least rainfall in history. At the other extreme is an estimated flow of 83,400 sec.-ft. into the same reservoir in July, 1916. Under these conditions without the present co-ordinated storage and water use arrangement, little prime power would be produced. But with the flow as now regulated and controlled, 1,400,000,000 kw.-hr. of electrical energy has been produced annually for several years.

Relatively little water is now lost by having to spill it over the dam at the several power plants. When and if the other possible sites on the river are developed, the loss of water by spillage will be further reduced.

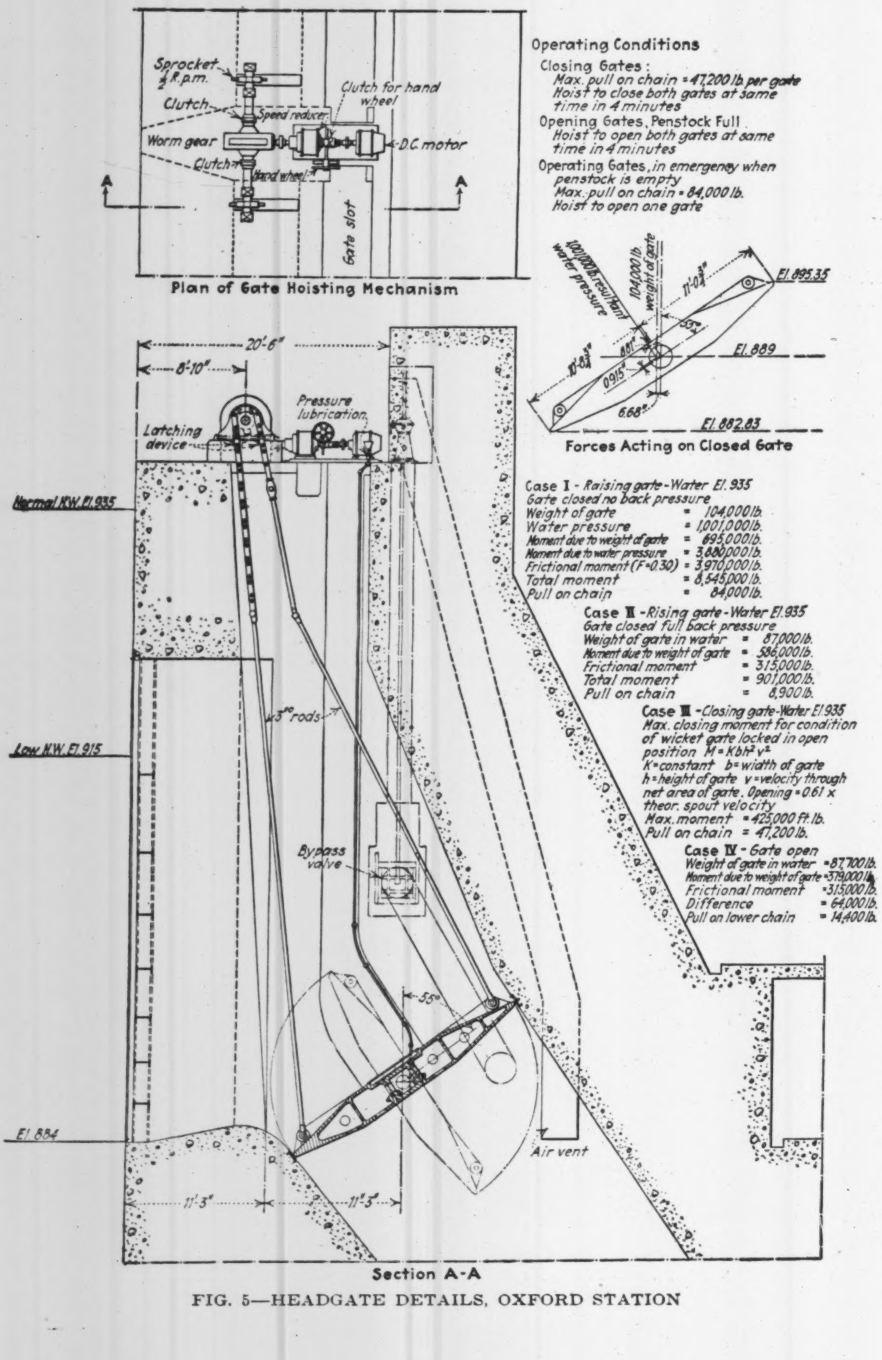
As new dams have been added and the possibilities of storage and control increased, added power has become available at the older dams through the increase in the regulated flow. This is particularly true in the case of the eighth and ninth dams downstream. The original installation at both these dams had a rated capacity of 41,600 hp. With the better control of the flow of the river, it has been possible to add 51,000 hp. at the eighth and 54,000 hp. at the ninth dam.

Flood Protection—To just what extent the storage reservoirs on the river have reduced flood damage cannot be accurately determined, but the October, 1929, flood gives a fair picture of the situation. That flood, taking the watershed as a whole, was not as great as the flood of July, 1916, but the south fork of the Catawba carried more water during this latter storm than it did in July, 1916. The total runoff due to the 1929 flood was very high over the entire watershed, yet there was practically no flood damage anywhere along the river. Under very similar conditions in 1916 there was an almost complete demoralization of all lines of transportation and communication and great property loss. The 1929 flood followed a period of unusually heavy precipitation for the late summer and early fall. Consequently the damage could not be controlled simply by complete holding back of the water; control could come only through a flattening of the flood peak. The flattening was accomplished by a skillful manipulation of the reservoirs along the river, once it was realized that a major flood was impending.

Operating the System—The operation of the system must conform to two variables which do not permit the setting up of a formula for operation. The variables are the load on the system and the runoff. The load fluctuates hourly, daily, weekly, monthly and annually. Some fluctuations are due to seasonal changes, others to general business conditions, crops and holidays. With a background of 25 years' experience in serving the territory, the company can gage fairly accurately the load requirements and the effects of the shutting down of plants for meal hours, Saturday afternoons and fixed holidays. Commercial requirements and the annual increase also can be estimated fairly closely.

Variations in runoff can be anticipated and provided for in seasonal operating policies for the water-power plants. In general, water is conserved through the period from Jan. 1 to the end of the summer rains for use during the normally dry fall season. But abnormal seasons and cyclic changes preclude any fixed seasonal operating program beyond these general principles.

When it comes to day-by-day and week-by-week policies for handling the river, they must be determined as the load and immediate storage and runoff conditions dictate. To check the runoff possibilities, very accurate rainfall and weather records are maintained at all the ten dams of the system. The operators at each plant report these records regularly by telephone to a central load dispatcher in the main office at Charlotte. If a storm occurs, the local observer reports hourly the amount of rainfall, the stage of his reservoir and other pertinent information.



Plan of Gate Hoisting Mechanism

Operating Conditions

Closing Gates:
Max. pull on chain = 47,200 lb. per gate
Hoist to close both gates at same time in 4 minutes
Opening Gates, Penstock Full
Hoist to open both gates at same time in 4 minutes
Operating Gates, in emergency when penstock is empty
Max. pull on chain = 84,000 lb.
Hoist to open one gate

Forces Acting on Closed Gate

Case I - Raising gate - Water El. 935
Gate closed no back pressure
Weight of gate = 104,000 lb.
Water pressure = 1,001,000 lb.
Moment due to weight of gate = 695,000 lb.
Moment due to water pressure = 3,880,000 lb.
Frictional moment (F = 0.30) = 3,970,000 lb.
Total moment = 8,545,000 lb.
Pull on chain = 84,000 lb.

Case II - Rising gate - Water El. 935
Gate closed full back pressure
Weight of gate in water = 87,000 lb.
Moment due to weight of gate = 586,000 lb.
Frictional moment = 315,000 lb.
Total moment = 901,000 lb.
Pull on chain = 8,900 lb.

Case III - Closing gate - Water El. 935
Max. closing moment for condition of wicket gate locked in open position $M = Kbh^2v^2$
K = constant b = width of gate
h = height of gate v = velocity through net area of gate. Opening = 0.61 x theor. spout velocity
Max. moment = 425,000 ft. lb.
Pull on chain = 47,200 lb.

Case IV - Gate open
Weight of gate in water = 87,700 lb.
Moment due to weight of gate = 379,000 lb.
Frictional moment = 315,000 lb.
Difference = 64,000 lb.
Pull on lower chain = 14,400 lb.

Section A-A

FIG. 5—HEADGATE DETAILS, OXFORD STATION

With the accumulated experience of the organization, the handling of the waterwheels of the several plants is ordinarily a matter of routine. The general scheme is to flatten out flood crests so that no water spills over any dam. If a local storm occurs midway on the system and its magnitude is such as to indicate a runoff in excess of the capacity of any set of wheels below that point, full load is at once shifted to that plant. At the same time enough wheel gates are opened right on downstream in progression to use the flow in excess of the available unused or desired reserve storage capacity.

Local storms rarely upset the general operating scheme. The storage facilities are so great and the reserve capacity in installed water wheels is so large that all the water from an ordinary storm can be converted into usable flow. It is the off-season and unheralded long swings of deficient ~~or ex~~cess precipitation that require the most skillful use of the data gathered during the life of the system.

So far as the auxiliary steam plants of the system are concerned, any fluctuations in load are handled by manipulation of the water-power plants so that while the steam plants are in operation they may be operated at maximum efficiency.

Hydraulic Structure — The great storage reservoir at the head of the chain of power plants is created by an earth-fill dam 165 ft. high, one of the highest of its type in the world. All the other dams are of the overflow gravity-section type built of concrete. All are founded on granite-ledge rock free from fissures and faults. The rock is so sound that no aprons have been provided at the downstream toe of any of the dams and practically no scour has occurred below any of them.

The Catawba is a muddy water stream, but a large part of the material which clouds it is colloidal and does not settle in the reservoir. The little silt which does accumulate is so small a fraction of the capacity of the reservoir that it need not be taken into consideration within a period far beyond present calculations of obsolescence.

Details of Design—Out of the quarter of a century of experience in the construction and operation of large hydro-electric developments on the Catawba River, the engineering department of the Duke Power Co. has acquired a vast amount of knowledge of the most economical and effective design for various features of such undertakings on this stream. A survey of the last plant built, known as the Oxford project, shows a ruggedness and simplicity in both general design and in details. Of special significance among these features are the flood gates and the equipment auxiliary to them. The gates which control the entrance to the waterwheels also are worthy of note on account of their effective application to the problem presented.

In the earlier dams no provision was made for regulation of the reservoir pond level by means of flood gates on the crests of the spillways. Later, as experience began to be acquired in handling the river, the value of such control works became very evident. As a result, the more recently built developments have been equipped for a wide range of pond-level control. The latter also have been added on two previously built dams. Whether it will be practicable to supplement others of the early dams in this manner depends on the effect of altered heads above or below the range of those that give the greatest efficiency for wheels in the respective power plants. Raised tailwater levels also are a factor.

Details of Gates—A comparison of the spillway gates on the dam of the Catawba station with those at the Oxford plant indicates the progress that has been made in the design of this feature. In Fig. 4 is shown a view of the Catawba project looking upstream in which are shown the traveling cranes which handle the gates. Here vertical motor-driven screws raise and lower the gates. At the Oxford plant, gantry cranes with chain lifts handle the gates.

An analysis of the design of the spillway gates of the Oxford plant also shows their simplicity. The ten vertical flood-control gates of this project are set between piers built up from the crest of the spillway. Each gate provides a clear opening 25x45 ft. when fully raised. The total estimated capacity of all ten gates is 209,000 sec.-ft., which is about 25 per cent in excess of the greatest flood of record in the river at this point.

Figs. 6 and 7 show detail and general features of

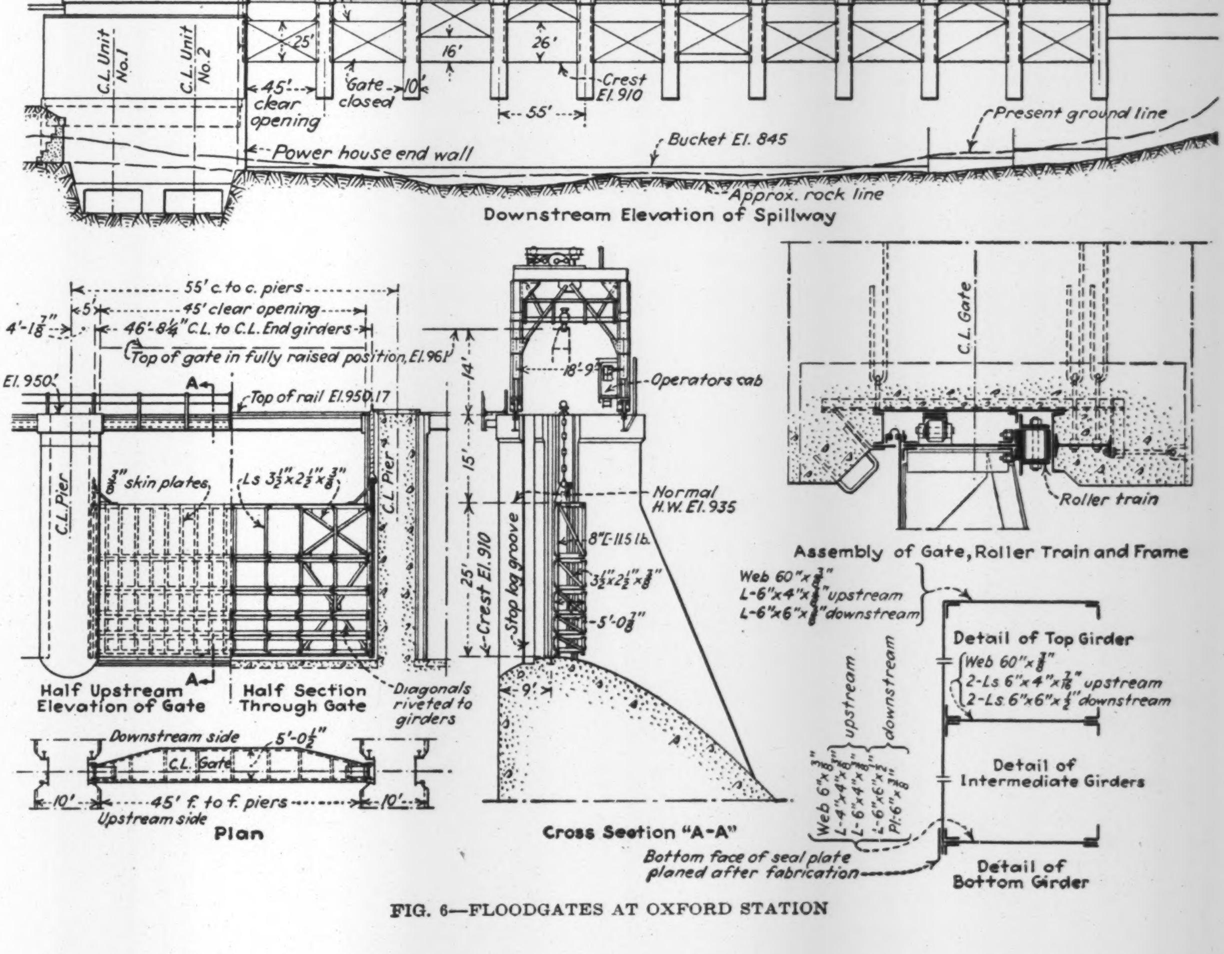

10 gates 55' c. to c. piers = 550'
Gate in partly raised position
Gate in fully raised position
Top of gate El. 935
Top of piers El. 950
C.L. Unit No. 1
C.L. Unit No. 2
25'
16'
26'
45' clear opening
Gate closed
10'
Crest El. 910
55'
Present ground line
Bucket El. 845
Power house end wall
Approx. rock line
Downstream Elevation of Spillway
55' c. to c. piers
5'
45' clear opening
4'-1 7/8"
46'-8 1/4" C.L. to C.L. End girders
Top of gate in fully raised position, El. 961
El. 950
A
Top of rail El. 950.17
C.L. Pier
3/8" skin plates
Ls 3 1/2" x 2 1/2" x 3/8"
C.L. Pier
Half Upstream Elevation of Gate
Half Section Through Gate
Diagonals riveted to girders
Downstream side
5'-0 1/2"
C.L. Gate
10'
45' f. to f. piers
10'
Upstream side
Plan
14'
15'
25'
Crest El. 910
18'-9"
Operators cab
Normal H.W. El. 935
8" [-11.5 lb.
3 1/2 x 2 1/2 x 3/8"
5'-0 7/8"
Stop log groove
9'
Cross Section "A-A"
C.L. Gate
Roller train
Assembly of Gate, Roller Train and Frame
Web 60" x 3/8"
L-6" x 4" x 3/8" upstream
L-6" x 6" x 3/8" downstream
Detail of Top Girder
Web 60" x 3/8"
2-Ls 6" x 4" x 7/16" upstream
2-Ls 6" x 6" x 1/2" downstream
Detail of Intermediate Girders
upstream
downstream
Web 6" x 3/8"
L-4" x 4" x 3/8"
L-6" x 4" x 3/8"
L-6" x 6" x 1/2"
Pl-6" x 3/8"
Bottom face of seal plate planed after fabrication
Detail of Bottom Girder

FIG. 6—FLOODGATES AT OXFORD STATION

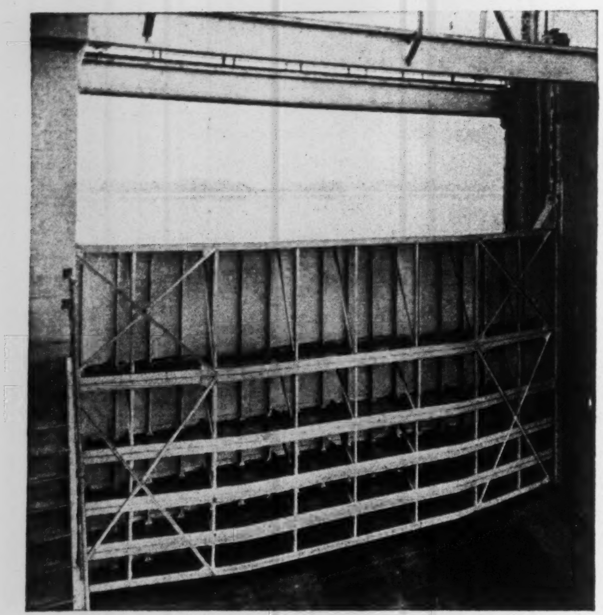


FIG. 7—DOWNSTREAM SIDE OF OXFORD FLOODGATE

these gates. Attention is called particularly to the simplicity of design of the ends and lower edge and to the guides in which the gates travel. The effectiveness of this design is indicated by the fact that there is practically no leakage through the joints thus formed after the gates have seated under the full head for which they were designed. It should be noted, also, that no provision had to be made in the design for ice conditions in the pond.

The chains, by which the fall blocks on the traveling cranes lift the gates, are so designed that any gate may be hooked in place at 3-ft. intervals in its vertical travel by means of lugs.

Headgates—Similar simplicity has been obtained in the design of the butterfly valves used as headgates at Oxford.

One motor-driven hoist designed for outdoor operation handles the pair of gates for each of the two 28,000-hp. waterwheel units in the plant. This hoist is provided with two clutches so that either gate may be operated separately, or both at the same time. On the hoist shaft are two large sprockets, one for a chain by means of which each of the two gates are operated. The length of this chain is sufficient to provide the travel necessary to move the gate from a closed to a fully open position. Hinged rods attached to the ends of the gate span the balance of the distance from the hoist to the gate. The hoist is designed to open or to close both gates at the same time in four minutes. When closing them with the penstock full, the pull on the chain per gate is 47,000 lb. For emergency conditions, when the penstock is empty, the hoist is required to open one gate at a time only, with a pull of 84,000 lb. on the chain.

Either or both of the twin-penstock entrances to each of the waterwheels of this station may be closed off by means of stoplogs in the headwall of the power-house structure that carries stationary steel trash racks. An air vent extends from the gate-hoist floor down to the space beyond the gate, so that the latter will not become airbound when the water in the tailrace is high enough to seal the draft tube and penstock. A bypass valve set in the partition wall between the twin penstocks of each wheel also permits either penstock to be drained through the other.

Very satisfactory results have been obtained with this type of gate and its operating mechanism. In fact, no difficulties whatever have been experienced with either under a wide range of head and load conditions.

The hydro-electric projects of the Duke Power Co. were designed by the engineering department, and were either built by or under the supervision of the construction division of the company. W. S. Lee is chief engineer and vice-president of the Duke Power Co.

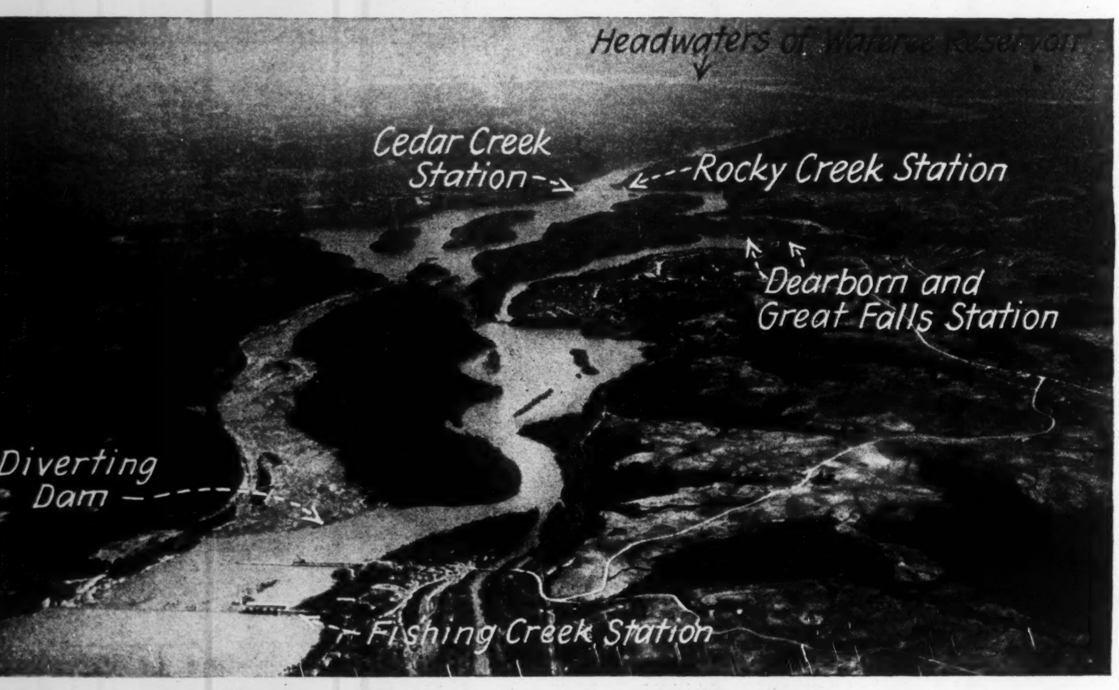


FIG. 8—FIVE POWER STATIONS ON THE CATAWBA RIVER

Industrial Research Acquires a Million Dollar Plant

New Kensington Laboratory for Study of Aluminum Provides for Staff of 150, Dealing With a Wide Range of Problems in Fields From Paint to Structures

By Henry Hornbostel
Architect, Pittsburgh, Pa.

Since the time of Charles M. Hall's discovery of the present-day aluminum production process, research in aluminum technology has developed to a high degree. The new building of the Aluminum Research Laboratories, at New Kensington, Pa., is typical of the manner in which the Aluminum Company of America is striving to promote its research activities. The Aluminum Research Laboratories maintain branches in Baden, N. C., Buffalo, Cleveland, East St. Louis, Ill., and Massena, N. Y., for the investigation of special problems. The new central laboratory is located on a fourteen-acre tract 20 miles north of Pittsburgh and near the company's main fabricating plant. The building is U-shaped, with main part 275 ft. long and wings 108 ft. deep, mainly two stories high, 56,000 sq.ft. of floor space, to accommodate the present research staff of 150, formerly housed in the fabricating plant. Future extension by a similar structure to complete a hollow square is provided for. The structure, as well as its equipment, uses aluminum extensively. Both the carefully studied layout of working spaces and the architecural conception make the laboratory noteworthy. The architect describes his work in the following notes. —Editor.

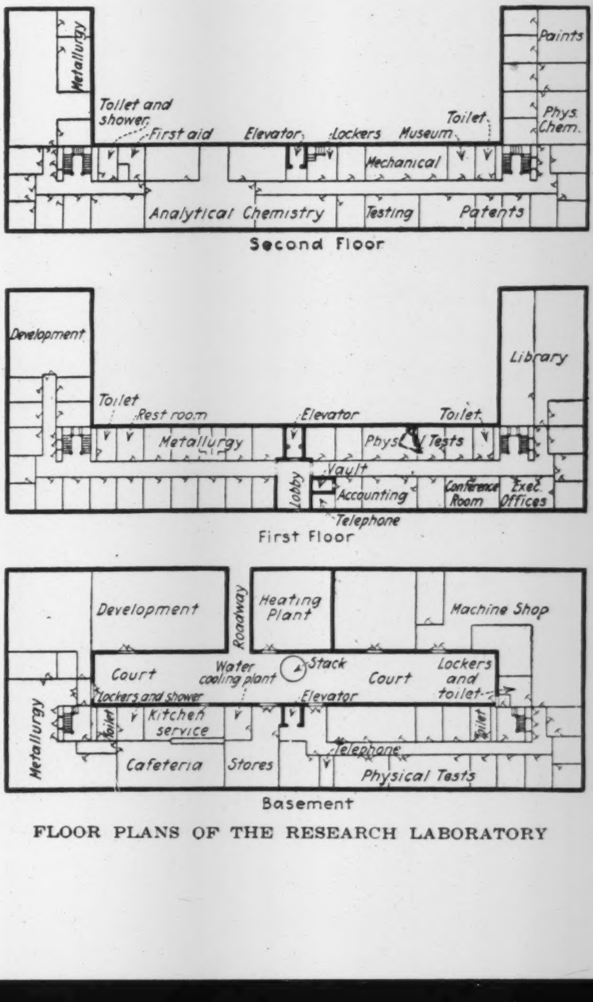
In the great development of industrial research laboratories in this country much wisdom has been displayed by the industries. Establishing these centers of scientific investigation and discovery, with their extensive beneficial results, has involved bringing together a great army of scientific men not only of this country but from abroad, and the installation of refined equipment. All this has produced an atmosphere favorable to stimulation of scientific thought, of imagination and of truth-seeking. Each nucleus represents a family of highly trained men functioning in ideal surroundings, free from commercial embarrassment and looking forward to the possibility of important discoveries. The members of this family all have one point of view: to investigate every possible scientific quality of the materials and processes with which their industry deals.

The laboratory of the Aluminum Research Laboratories, at New Kensington, is unique among these institutions. It is unusual that a research laboratory for a definite material should be able to use this material to construct and embellish its own building. All scientific desiderata seem to have been attained at New Kensington. A laboratory of exceptional perfection of equipment, efficient in layout, is housed in a dignified and interesting building placed on a prominent site in the Allegheny Mountains, overlooking the Allegheny River and surrounded by beautiful landscape gardening. It may be observed that the scientific mind is just as amenable to the influence of artistic surroundings as is that of the ordinary individual. Future growth also is provided for as the building can easily be doubled in size.

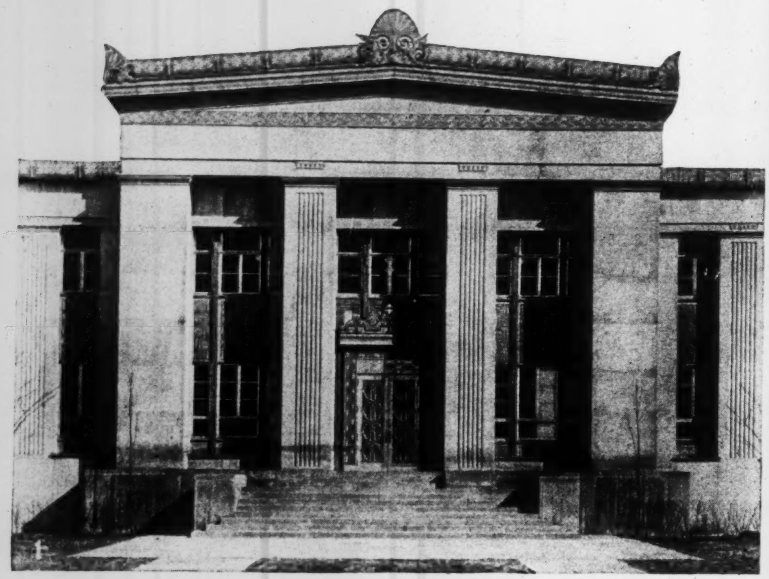
The building itself is a practical model of the many uses and applications of aluminum. On the exterior the cornices, copings and exterior portals are of cast aluminum, partly covered with a salt-glaze baked on the material to give polychrome effects. The window frames and sashes are of extruded metal. The entrance gate is of forged aluminum and is an artistic accomplishment of great interest. In the interior the terrazzo floors are marked out with aluminum strips. Doors are embellished with decorative hammered aluminum panels. The building is furnished with aluminum furniture of tubular and cast construction.

The building is well lighted, well ventilated, and so arranged that its nervous system—pipes, conduits, etc.—can be easily reached for any shifting or modification of laboratory machinery; a pipe chase at each exterior column carries these service elements. The rooms are well co-ordinated and have different ceiling heights to accommodate the different equipment used. With its cafeteria and other conveniences and comforts, the building is likewise a delightful clubhouse.

All the piping for hot and cold water is aluminum,


Metallurgy
Paints
Toilet and shower
First aid
Elevator
Lockers
Museum
Toilet
Phys. Chem.
Mechanical
Analytical Chemistry
Testing
Patents
Second Floor
Development
Library
Toilet
Rest room
Elevator
Toilet
Metallurgy
Phys. Tests
Vault
Lobby
Accounting
Conference Room
Exec. Offices
Telephone
First Floor
Development
Roadway
Heating Plant
Machine Shop
Court
Water cooling plant
Stack
Court
Lockers and toilet
Lockers and shower
Elevator
Metallurgy
Toilet
Kitchen service
Toilet
Telephone
Cafeteria
Stores
Physical Tests
Basement

FLOOR PLANS OF THE RESEARCH LABORATORY



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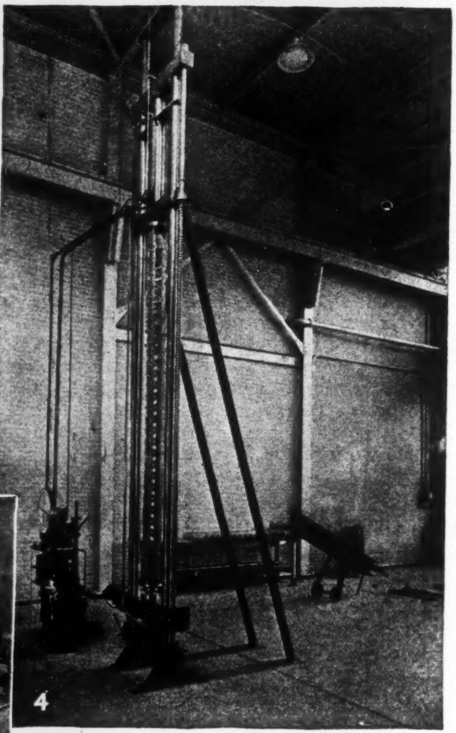
Some Details of New Research Laboratory at New Kensington, Pa.

Extensive use was made of cast and wrought aluminum in the construction. Much of the exterior trim is cast aluminum—cornice, coping, belt courses, spandrel panels, mullions, doorframes (Fig. 1). Part of this metal is coated with vitreous enamel in colors, part is polished, part natural sandcast finish. A large amount of interior piping (some of it visible in Fig. 2, metallurgical laboratory, with furnaces and sheet rolls) is drawn aluminum and alloy. Pipes and ducts are made accessible throughout the building by being carried up in chases at outside columns (Fig. 2). The building houses a staff of about 150.

The lower four views are in the mechanical laboratory. Fig. 3 shows part of a battery of endurance-testing machines, one of the largest groups in existence. A 40,000-lb. vertical Amsler machine (Fig. 4) will take tension and compression specimens up to 10 ft. long; a 300,000-lb. machine is yet to be installed. Torsion testing (Fig. 5) and other work are fully provided for. There are many facilities for special testing, as exemplified by Fig. 6, showing a box girder of aluminum alloy under flexure test; hold-down bolts restrain the ends, and a lifting jack at midspan applies load.



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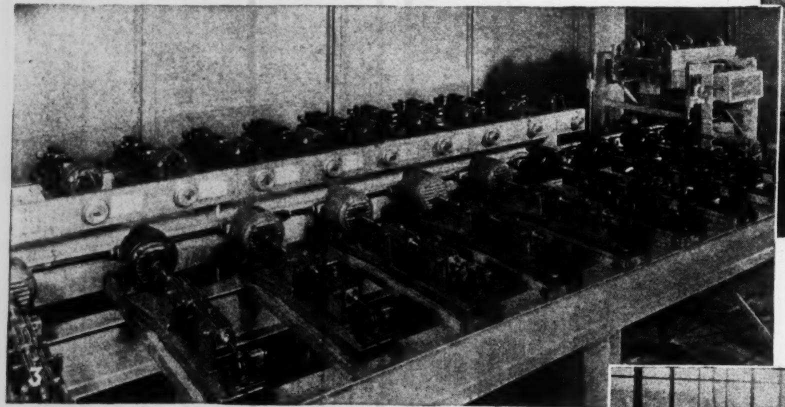

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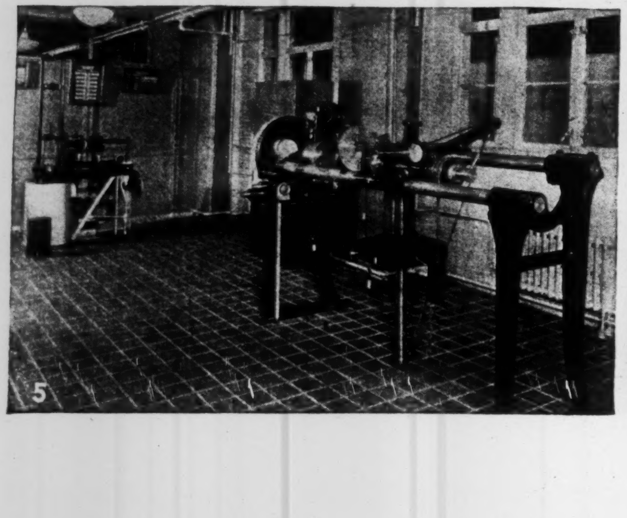

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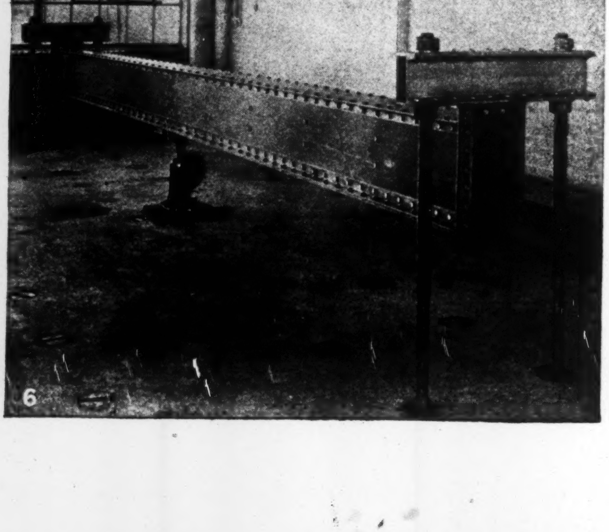

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ALUMINUM RESEARCH LABORATORIES, NEW KENSINGTON

Dimensions—Site, fourteen acres; building, 275 ft. long with 108-ft. wings at ends; floor space, 56,000 sq.ft. Pipe chases at every column contain air, water, gas and drain pipes and electrical conduit. Chase is built in removable sections so that by removal of two or three screws, part of the supply system may be exposed.

Blowers attached to all chemical hoods. These blowers alone are sufficiently powerful to change all the air in the building in twenty minutes.

Cost of Building and Equipment—About $1,000,000.

Director—Dr. Francis C. Frary; assistant directors, Junius D. Edwards and H. E. Bakken.

Aluminum in Structure and Equipment—Fence, gate, main door, window frames, spandrels, mullions, cornices, balustrades, elevator, elevator door (hand-hammered aluminum sheet), inlay in terrazzo floor, stair treads, lighting fixtures, radiator pipes and grills, all water pipes, distilled water tank, benches in chemical laboratories, overhead traveling crane, desks and chairs, aluminum cases for balances, cafeteria tables and chairs, etc.

Laboratory Divisions—Metallurgical division works on the development of new alloy compositions and processes as well as on the perfection of old alloy compositions and processes.

Physical testing division determines the physical properties of aluminum and its alloys and studies related engineering problems.

Chemical development division handles both small- and large-scale problems of a chemical nature relating to the production of alumina and other chemical products and byproducts.

Mechanical division devotes its time to machine development.

Paints and finishes division studies the problems connected with aluminum paint and with the application of other paints and finishes to aluminum surfaces.

Patent division secures and classifies every patent, both foreign and domestic, which appears to be of interest in connection with the company's operations.

Analytical chemistry division investigates and establishes standard analytical methods for the company's seventeen plant laboratories; studies the chemical or corrosion behavior of aluminum in various industrial uses; maintains sales service laboratory, which renders assistance to sales department on problems involving chemical behavior of the metal.

Physical chemistry division handles precise measurements of a physical nature.

Outstanding Equipment of the Laboratories—Many types of electrically heated furnaces with compensating thermocouples and precision potentiometers. All furnace equipment is painted with aluminum paint in order to reduce radiation losses.

15 kva. high-frequency induction furnace.

Zeiss microscopes and instruments for making photomicrographs.

Large microscopic equipment set on rubber "shock absorbers."

Gas-fired and electrical ovens; pressure digesters; crushing, grinding and pulverizing machinery; sieves and classifiers; apparatus to measure absorption efficiency of activated alumina.

Amsler universal testing machine with seven capacities from 400 to 40,000 lb.; Amsler universal testing machine with four capacities from 30,000 to 300,000 lb.

300,000-lb. Amsler hydraulic testing machine, taking tension or compression specimens up to 10 ft. in length, or beams with a maximum span of 10 ft.; two smaller Amsler hydraulic machines.

3-ton aluminum alloy crane.

Aluminum distilled water tank.

Universal floor test slab.

Amsler torsion testing machine, with capacities ranging from 240 to 1,200 ft.-lb.

Two Olsen wire-testing machines, each having capacities of 1,000 and 10,000 lb.

Fatigue-testing machines, including twenty R. R. Moore rotating-beam machines, eight constant deflection-constant stress fatigue machines for sheet metal, four direct tension fatigue-testing machines, one cantilever specimen type of machine for testing aluminum tubing and fittings.

Foil-testing equipment.

including the tanks and pipes for distilled water. The radiators are composed of horizontal aluminum tubing with vertical aluminum fins. Stair treads, balustrades, handrails, hardware, lighting fixtures, switch plates, and even the lightning rod, are made of aluminum. Much of the necessary machinery, such as traveling cranes, has been constructed of alloys of this same material.

The ensemble has been executed in a modern efficient method, and in addition has been made beautiful. The whole enterprise is an extremely interesting example of scientific engineering efficiency, combined with artistic striving, displaying the good judgment of those who have brought about the execution of this monument.

Typhoid Death Rates in American Cities of More Than 100,000 Population

THE *Journal* of the American Medical Association has completed its eighteenth annual summary of typhoid death rates in cities of the United States of more than 100,000 population, and the accompanying figures are taken from the columns of its issue of May 17, 1930. The rates are based on estimated midyear populations. Five cities, Duluth, Hartford, New Bedford, Reading and Spokane, have a perfect record.

Death Rates Per 100,000 Population in 1929

0.0 to 1.9 (53 Cities)

DULUTH	0.0	Erie	0.7	Flint	1.3
HARTFORD	0.0	Fall River*	0.7	Scranton	1.4
NEW BEDFORD	0.0	Jacksonville	0.7	Indianapolis	1.5
READING	0.0	Philadelphia	0.7	Richmond	1.5
SPOKANE	0.0	Salt Lake City*	0.7	St. Louis	1.5
Jersey City	0.3	Springfield, Mass.*	0.7	Boston	1.6
Toledo	0.3	Canton	0.8	Cambridge, Mass.	1.6
Milwaukee	0.4	Wilmington	0.8	Dayton	1.6
Omaha	0.4	Detroit	0.9	San Diego	1.6
Cleveland	0.5	Utica*	0.9	Yonkers	1.6
Norfolk	0.5	New Haven	1.0	Akron	1.7
Syracuse	0.5	St. Paul	1.0	Elizabeth	1.7
Bridgeport	0.6	San Francisco	1.0	Providence	1.7
Chicago	0.6	Worcester	1.0	Tacoma	1.7
Grand Rapids*	0.6	Youngstown	1.0	Buffalo	1.9
Minneapolis	0.6	Los Angeles	1.1	Cincinnati	1.9
Newark	0.6	Oakland	1.1	Lynn	1.9
Rochester, N. Y.	0.6	New York	1.2		

2.0 to 4.9 (20 Cities)

Denver	2.0	Seattle	2.3	San Antonio	3.1
Paterson	2.0	Washington	2.3	Des Moines	3.2
Trenton	2.1	Kansas City, Kan.	2.5	Kansas City, Mo.	3.2
Tulsa	2.1	Baltimore	2.6	Albany	3.3
Columbus	2.3	Louisville	2.6	Lowell	4.4
Pittsburgh	2.3	Fort Worth	2.8	El Paso	4.9
Portland, Ore.	2.3	Houston	2.8		

5.0 to 9.9 (7 Cities)

Camden†	5.8	Oklahoma City	6.2	Birmingham†	7.0
Memphis	6.2	Atlanta	6.5	New Orleans	9.1
				Dallas	9.4

Above 10.0 (1 City)

Nashville	12.8

*In Fall River, Grand Rapids, Salt Lake City, Springfield, Mass., and Utica, N. Y., the only typhoid deaths reported were of non-residents.

†Cities in which a considerable proportion of the total typhoid deaths for 1929 was of non-residents are (see also preceding footnote): Pittsburgh, 12 non-resident, total for city, 16; Camden, 5 non-resident, total for city, 8; Birmingham, 9 non-resident, total for city, 16.

Number of Cities With Various Typhoid Death Rates

	No. of Cities	10.0 and Over	5.0 to 9.9	2.0 to 4.9	1.0 to 1.9	0.1 to 0.9	0.0
1906-1910	74	72	2	0	0	0	0
1911-1915	75	55	18	2	0	0	0
1916-1920	77	19	29	29	0	0	0
1921-1925	79	8	15	46	10	0	0
1926	80	6	10	27	10	14	4
1927	81	4	8	26	23	13	7
1928	81	4	6*	25	20	17*	9
1929	81	1	7	20	25	23	5

*Revised from figures given in 1928 report on account of correction for Erie

Total Typhoid Rate for 74 Cities, 1910-1928*

	Pop. Millions	Typhoid Deaths	Typhoid Death Rate Per 100,000		Pop. Millions	Typhoid Deaths	Typhoid Death Rate Per 100,000
1910	22.3	4,586	20.58	1920	28.2	1,074	3.81
1911	22.9	3,883	16.94	1921	28.5	1,130	3.96
1912	23.5	3,077	13.07	1922	28.9	955	3.30
1913	24.2	3,222	13.34	1923	29.6	936	3.16
1914	24.8	2,744	11.07	1924	30.2	937	3.11
1915	25.4	2,373	9.34	1925	30.9	1,007	3.45
1916	25.9	2,154	8.31	1926	31.7	895	2.83
1917	26.5	1,963	7.40	1927	32.5	638	1.96
1918	26.7†	1,796†	6.72	1928	33.1	621‡	1.89‡
1919	27.4†	1,141†	4.17	1929	34.0	531	1.56§

*The following seven cities are omitted because data for the full period are not available: Canton, Dallas, Jacksonville, Oklahoma City, Tulsa, Utica, Wilmington.

†Lacks data for Forth Worth. ‡Revised from figures given in 1928 report on account of correction for Erie.

§The rate for the 81 cities in 1929 is 1.62.

Total Typhoid Death Rate for 81 Cities According to Geographic Divisions

(Rearranged in Order of 1929 Rates—Ed. *E. N.-R.*)

	1929 Population	1929		1928				
		Deaths	Rate	Deaths	Rate	1927 Rate	1926 Rate	1925 Rate
East North Central	8,715,100	75	0.86	94	1.10	1.31	1.69	2.19
Middle Atlantic	12,034,265	149	1.24	171*	1.45*	1.41	2.09	2.97
New England	2,575,282	34	1.32	23	0.90	1.26	1.51	2.37
Mountain & Pacific	4,001,445	54	1.35	72	1.92	1.74	1.98	2.19
West North Central	2,636,300	41	1.55	43	1.65	1.86	2.22	3.31
South Atlantic	2,321,300	58	2.50	85	3.72	3.39	5.38	5.71†
West South Central	1,875,054	104	5.55	109	6.18	6.71	11.69‡	13.27‡
East South Central	899,915	55	6.11	68	7.68	10.07	14.47	14.30

*Revised from figures given in 1928 report on account of correction for Erie.

†Lacks data for Jacksonville. ‡Lacks data for Oklahoma City.

Alternate Stages and Critical Depth in Circular Hydraulic Conduits

By Thomas R. Camp
Associate Professor of Sanitary Engineering, Massachusetts Institute of Technology

In the design of open-channel transitions it is convenient to know the location of the alternate hydraulic stages at which flow can take place and the value of the critical depth for the available energy. Much has been written about these factors for rectangular channels and trapezoidal channels, but there is little information available in print concerning alternate stages and critical depth for circular pipes. As circular conduits are so widely used for storm and sanitary sewers, this information is of particular value to the sanitary engineer.

The writer has endeavored to collect and put these data into general form so that the stages of flow and critical depths can be obtained with facility for any discharge and for any size conduit within the usual ranges. All the data have been plotted upon the accompanying chart. For the derivation of the formulas and the explanation of the compilation and use of the chart, the usual hydraulic notation will be used as follows:

D = diameter of conduit in feet.
d = depth of flow in middle of conduit in feet.
Q = discharge in second-feet.
A = full section area of conduit in square feet.
a = section area of conduit at depth, d.
v = velocity in feet per second $= \frac{Q}{a}$.
H = total energy head in feet, measured from invert of conduit.

Now, from Bernoulli's theorem,

$$H = d + \frac{v^2}{2g}$$

$$= d + \frac{Q^2}{2ga^2} \quad (1)$$

Whence

$$(H - d) = \frac{Q^2}{2ga^2} \quad (1a)$$

$$1 - \frac{d}{H} = \frac{Q^2}{2gHa^2}$$

and if

$$x = \frac{d}{H}$$

$$1 - x = \frac{Q^2}{2gHa^2} \quad (2)$$

For rectangular channels, a may be readily expressed in terms of x and H; and equation (2) becomes a cubical equation in terms of x. B. F. Groat has offered a ready means for solving this equation by plotting values of $\frac{Q^2}{2gH^3}$ as abscissas against values of x as ordinates. (See *Trans.*, Am.Soc.C.E., Vol. LXXX, 1916, p. 338, discussion of paper by Karl R. Kennison.) Computed values of x for rectangular channels have also been tabulated in King's "Handbook of Hydraulics," second edition.

A similar treatment for circular conduits meets with the difficulty that a is a complicated function of the diameter, D. The expression is

$$a = \frac{D^2}{4}\cos^{-1}\frac{D - 2d}{D} - \frac{1}{2}(D - 2d)\sqrt{Dd - d^2} \quad (3)$$

This expression cannot readily be put in terms of x.

For any value of $\frac{d}{D}$, however, $\frac{a}{A}$ is a constant independent of the value of D. Therefore,

$$a = CA = K_1D^2 \quad (4)$$

$$a^2 = C^2A^2 = K_1^2D^4 = KD^4 \quad (5)$$

where C, K_1 and K are constants.

$$K_1 = \frac{CA}{D^2} = \frac{\pi}{4}C \quad (6)$$

and

$$K = K_1^2 = \left(\frac{\pi}{4}C\right)^2, \quad (7)$$

a function of $\frac{d}{D}$. Substituting the value of a^2 from (5) in equation (2), (2) becomes

$$K(1 - x) = \frac{Q^2}{2gHD^4} \quad (8)$$

Values of $\frac{Q^2}{2gHD^4}$ as a function of x have been computed for various values of $\frac{d}{D}$ and have been plotted on the accompanying diagram as abscissas against the cor-

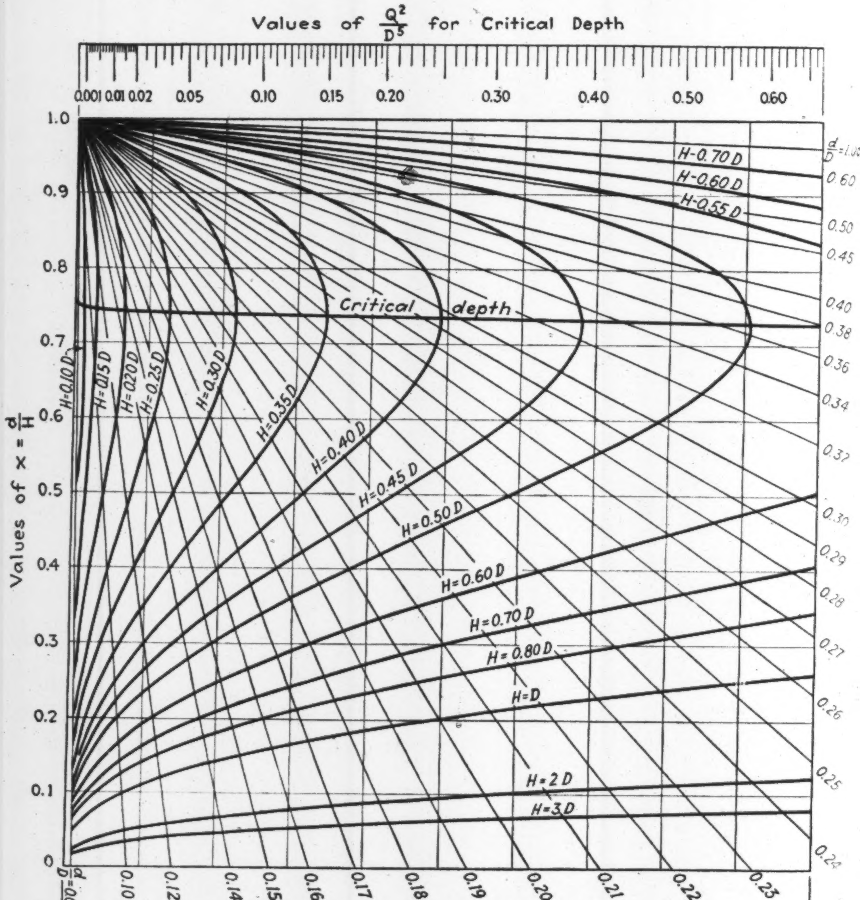


DIAGRAM FOR DETERMINING ALTERNATE STAGES responding values of x as ordinates. The result is a series of straight lines for the various values of $\frac{d}{D}$ which meet at a point when $x = 1.0$.

Now, if

$$\frac{d}{D} = C_1 \frac{d}{H}, H = C_1 D \qquad (9)$$

and for any value of C_1,

$$\frac{d}{D} = C_1 x \qquad (10)$$

Values of $\frac{d}{D}$ and x on this diagram have then been plotted for various values of C_1, giving the resulting curved lines.

Now for any given values of Q, D and H, the alternate stages may be determined directly from the diagram.

For example, let $D = 60$ in. $= 5$ ft.; $H = 7$ ft. $= 1.4D$, and $Q = 150$ sec.-ft. Then $\frac{Q^2}{2gHD^4} = 0.08$.

From the diagram, the value 0.08 intersects the curve for $H = 1.4D$ at $x = 0.32$ and $x = 0.87$. Therefore, the alternate stages are 2.24 ft. and 6.09 ft. respectively, and the pipe is under pressure of 1.09 ft. at the upper stage.

It will be noted from the diagram that the maximum value of $\frac{Q^2}{2gHD^4}$ for $H = 1.4D$ is approximately 0.20. Therefore, if Q is such as to give a value in excess of 0.20, the energy available is not sufficient to force this quantity through the pipe. When Q is just sufficient to give a value of $\frac{Q^2}{2gHD^4}$ equal to 0.20, x from the diagram is about 0.62 and the critical depth is 4.34 ft.

Since the values of x for the tangent points of the $\frac{H}{D}$ curves—that is, the critical depths—cannot be determined accurately from the diagram by scaling, it has become advisable to plot a critical depth line on the diagram.

From equation (1a),

$$Q^2 = 2ga^2(H - d)$$

$$\text{and } Q = a\sqrt{2g\,(H - d)} \qquad (11)$$

The value of a from equation (3) is substituted in (11) which becomes

$$Q = \sqrt{2g(H - d)}\left[\frac{D^2}{4}\cos^{-1}\frac{D - 2d}{D} - \frac{D - 2d}{2}\sqrt{Dd - d}\right] \qquad (12)$$

Differentiating this equation with respect to the depth d, and setting the derivative equal to zero, we obtain

$$H = d_c + \frac{D^2}{16\sqrt{Dd_c - d_c^2}}\cos^{-1}\frac{D - 2d_c}{D} - \frac{D - 2d_c}{8} \qquad (13)$$

which gives the value of H in terms of the critical depth, d_c.

The critical depth curve as computed from this equation has been plotted on the chart. It is to be noted that for a full conduit there is no critical depth.

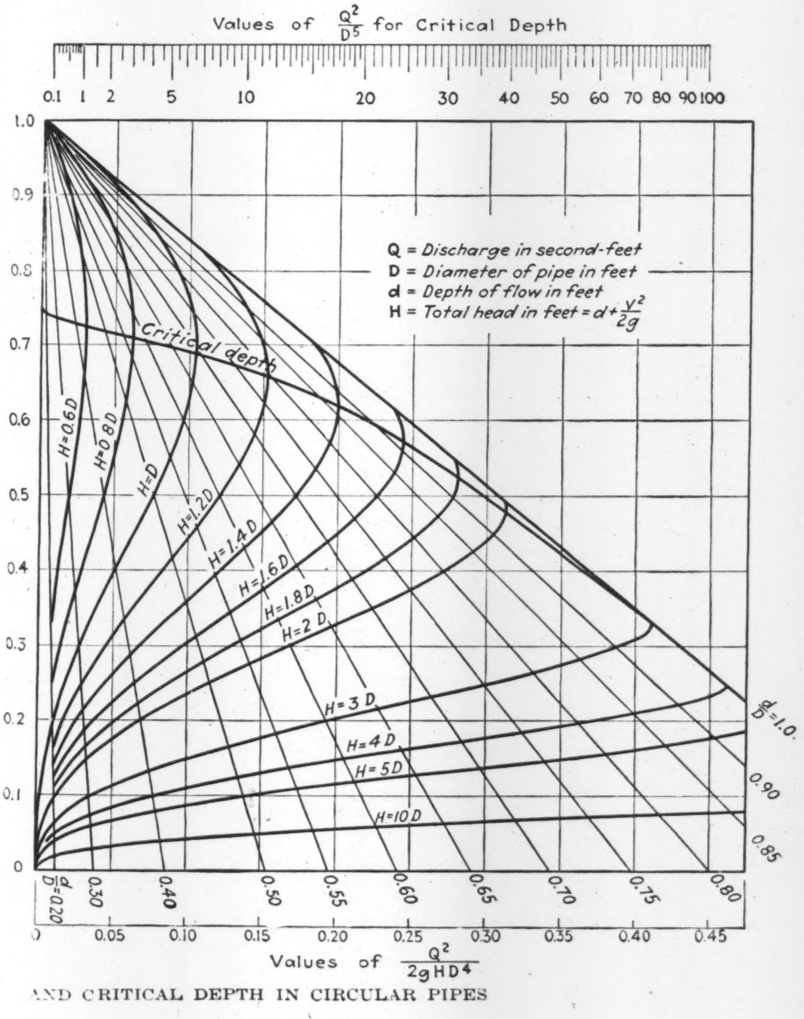
The scale at the top of the chart giving values of $\frac{Q^2}{D^5}$ has been added for the solution of critical depth problems when either Q or d is unknown. For example, to find the critical depth in a 5-ft. pipe for a discharge of 150 sec.-ft.

$$\frac{Q^2}{D^5} = \frac{22{,}500}{3{,}125} = 7.2.$$

This value on the chart intersects the critical depth line at $x = 0.685$ and $\frac{d}{D} = 0.70$. From this, the critical depth is found to be 3.5 ft. and $H = 5.11$ ft.

To find the maximum discharge through a 5-ft. pipe if $d = 3.0$ ft., the $\frac{d}{D} = 0.6$ line intersects the critical depth curve at a value of $\frac{Q^2}{D^5} = 4$. From this Q is found to be approximately 112 sec.-ft.

Tables for the determination of the critical depth in circular conduits which give more accurate values than the accompanying chart were prepared by Julian Hinds and published in *Engineering News-Record*, Vol. 87, Oct. 27, 1921, p. 693.



ND CRITICAL DEPTH IN CIRCULAR PIPES

Water-Works Problems and Practice

Abstracts of Papers on Diesel Engines, Test Coupons From Welded-Steel Pipe, Developing a Large Distribution System, Filter Sand Shrinkage, Pre-Ammoniation, Pre-Chlorination, Color Removal, Training Small-Town Filter Plant Operators

SUPPLEMENTING last week's report of the technical proceedings of the St. Louis convention of the American Water Works Association, in which notes on the many papers and discussions were reassembled by main topics, there follow here abstracts of seven papers. —EDITOR.

Diesel Engines for Water-Works Service

R. D. HALL
Manager Water Works Sales,
Worthington Pump & Machinery Company, New York City

THE diesel engine in water-works service is here to stay. Its simplicity, reliability and flexibility, as well as its high economy, have been fully established. It is suitable for both direct and indirect connection. Direct connection may be to reciprocating geared power pumps; screw pumps for low heads; electric generators for motor-driven pumps; and electric generator and power pump may be combined. Indirect connection may be through speed-increasing gears to centrifugal pumps for customary pressures and through belts to drive in smaller size pumps and other auxiliaries.

Of three lists supplied to me by the Diesel Engine Manufacturers' Association group A includes 84 diesel engines with an average of 150 b.hp. located at 52 water-works plants, with 66 per cent of the pumps centrifugal and 34 per cent displacement. Of the centrifugal pumps, 30 per cent have step-up gears, 39 per cent are motor driven and 31 per cent belt driven. In group B there are 74 engines with an average of 470 b.hp. located at 30 water and electric plants. Group C has 34 engines with an average of 215 b.hp. located at eighteen water-pumping plants classed as "miscellaneous." These figures confirm the conclusion of several recent writers that in water-works service diesel engines are best suited to plants of moderate size.

The two prime movers suited for most efficient variable speed operation over a reasonable range are the steam turbine and the diesel engine.

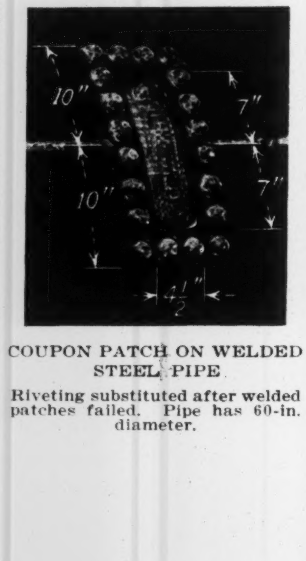
* * *

Failures of Welds on Small Patches in Large Steel Pipe

BY W. W. BRUSH
Chief Engineer, Department of Water Supply,
New York City

SPECIFICATIONS covering the fabrication of the ½-in. steel plate pipe for 60-in. trunk mains in New York City have been developed to the point where they require the rigid testing of small sections of the electrically welded joints. These small sections, or coupons, are usually 6x14 in. and are cut from a completed section of the pipe by means of a torch. The test consists of both tensile and cold bending stresses. In the former the coupon must show a strength equal to 100 per cent of the tensile strength of the plate, and it must bend around a 2½-in. pin without sign of fracture.

The openings made by the removal of the test pieces have been closed by welding a steel plate patch over the opening. Two of these patches have recently failed, one after being in use for about five months, and the other shortly after a mishap in construction whereby the pipe was floated above the trench bottom. The failures are attributed to high stresses set up by the cooling of the weld material between two sections of plate not free to move. In the first failure this stress was increased by the cold water carried by the pipe, and in the second by stresses incident to the pipe floating. Patches are now attached by riveting instead of welding, being applied to the inside of the pipe.



COUPON PATCH ON WELDED STEEL PIPE

Riveting substituted after welded patches failed. Pipe has 60-in. diameter.

* * *

Unusual Color-Removal Plant for Part of Los Angeles Water Supply

BY CARL WILSON
Director of Sanitation, Department of Water and Power,
Los Angeles, Calif.

DUE to the character of the sub-surface strata, the groundwater supply of Wilmington, Calif., now part of Los Angeles, contains a large amount of organic color, although there is little turbidity or hardness. With a low oxygen content and high organic material the water becomes unsightly in appearance and offensive in odor after standing for a few days. To render the supply suitable for use various color-removing agencies were tried, but were considered economically unsatisfactory.

Upon the appearance of ferric chloride in solution form on the local market, an experimental filter plant was constructed after laboratory tests had indicated the successful use of this material. Sand of 0.9 mm. effective size was used and found to be completely satisfactory. Because of difficulties encountered in backwashing, the filter bed thickness was reduced from 30 in. to 10 in., with crests of wash water troughs 10 in. above the surface. This thin bed and low freeboard gave most successful results. It was necessary to install a washing system capable of scouring the surface of the bed to prevent the growth of hard spots.

The amount of ferric chloride used as a coagulant, 0.2 grain per gallon, was so small that a catalytic action was suspected of the ferric hydroxide formed. Accordingly, tests were made of the repeated use of the sludge as a coagulating agent, and results showed that it could be used eleven or more times to produce a clear effluent. Filtration rates as high as 375 m.g.d. per acre were employed successfully. As a result of the experiments two filtration plants are being designed—one of 5- and one of 15-m.g.d. capacity.

* * *

Observations on Filter Sand Shrinkage

BY W. M. WALLACE
Superintendent of Filtration
ROBERTS HULBERT AND DOUGLAS FEBEN
Senior and Junior Chemists, Detroit Water Works

FILTER washing at Detroit throughout 1929 was done with a maximum available wash rate of 34 in. per minute vertical rise. This produced an average sand expansion of 36.4 per cent. The sand had previously been cleaned with a lye solution and subsequent hose scour, which removed 60 per cent of the coating substance accumulated during the previous five years. One year's trial of the full velocity wash indicates: (1) That recoating of the sand is greatly retarded and perhaps is entirely prevented; (2) shrinkage of the sand bed with consequent cracking along the filter walls has been greatly reduced; (3) the formation of mud shelves on the gravel against the filter walls, which greatly aggravates shrinkage, was prevented during the winter months and retarded during the summer; (4) maintenance of cleaner sand beds has increased the average filter run by at least 25 per cent.

It was found that even in a filter bed of perfectly clean sand, at a depth of 6 in. beneath the surface there was a greater hydrostatic pressure close to the filter wall than there was 6 in. away from it. This pressure difference, necessitating a horizontally directed flow of water, varied considerably in different filters and in proportion to the final degree of shrinkage exhibited by the bed. Mud deposits along the filter walls greatly aggravated this condition. Differences in velocity head, resulting in a smaller net pressure within the smaller pores, is suggested as the fundamental reason for the phenomenon. This difference in pressure has the final result of a horizontal compacting of the sand mass.

* * *

Preammoniation of Filtered Water at Cleveland, Ohio

By J. W. Ellms

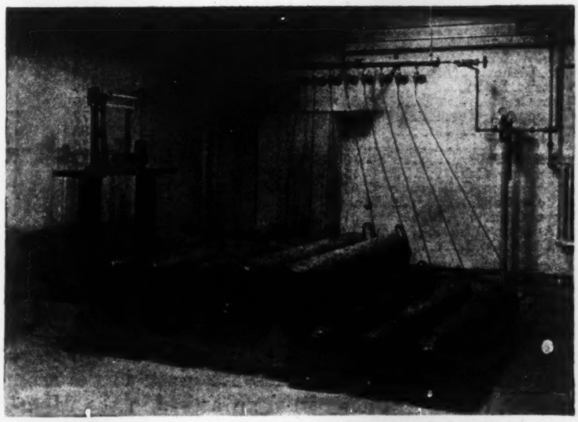
Engineer of Water Purification and Sewage Disposal, Cleveland, Ohio

APPLICATION of anhydrous ammonia to the filtered water prior to chlorination has been effective in eliminating chlorinous and chlorphenol taste and in improving the bacterial quality of the Cleveland water. Experimental work on taste prevention processes led to the adoption of this method in preference to that of activated carbon.

The products formed in the water are probably monochloramine and bichloramine, with the relative amount of the two compounds dependent on the hydrogen-ion concentration of the water. Formation of chlorphenolic bodies producing foul tastes is prevented by the presence of the ammonia. The disinfecting action of the chloramines is somewhat slower than that of chlorine alone, but the inhibitory effect upon bacterial growth continues for a longer time. Experiments on preammoniation showed that it would prevent objectionable taste from chlorphenolic compounds even when phenol is present in a concentration of 1 p.p.m. and that the taste would not be produced even when the treated water was boiled.

The process has been in use at one of the Cleveland filter plants since Nov. 1, 1929, and at the other plant since Jan. 4, 1930. At both plants the ammonia is applied to the water as a gas directly after filtration and prior to chlorination. The ratios of ammonia to chlorine applied at the two filter plants have been purposely varied from time to time. At one plant 2 lb. of ammonia to 3 or 3½ lb. of chlorine per 1 m.g. of water has been used, while at the other the quantities have varied from 1 lb. of ammonia to 2 to 3 or 3½ lb. of chlorine or ammonia to 3½ lb. of chlorine. No chlorphenolic taste has been noted in the supply while the ammonia has been used.

When preammoniation was in use at only one of the plants, four series of water samples were taken from the distribution system at opposite sides of the metropolitan district. The water which had been treated with the ammonia in addition to the chlorine had the lower baterial count at both 20 and 37 deg. The prolonged inhibitory effect on bacterial growth is of great value in maintaining a water in its highest state of purity throughout an extensive distribution system. The cost of preammoniation will not exceed 50c. per million gallons with ammonia at 15c. per pound.



EQUIPMENT FOR PRE-AMMONIATION AT CLEVELAND

Anhydrous ammonia pressure cylinders are connected by flexible steel tubing to a valved header on one end of which is an ammonia pressure gage. From the opposite end of the header a [illegible]-in. iron pipe conveys the gas to a dosing apparatus consisting of an orifice plate, a manometer and a control needle valve.

* * *

Training Operating Personnel for Small Purification Works

By J. Summie Whitener

Assistant Professor of Sanitary Engineering, North Carolina State College of Agriculture and Engineering, Raleigh, N. C.

SINCE its formation in 1919 the bureau of sanitary engineering of the North Carolina State Board of Health has assisted the small towns of the state in training the operating personnel of their water-purification works so that the plants might operate to the best efficiency. The training of technical and non-technical plant operators has increased plant efficiency, decreased operating costs, and raised the factor of safety against water-borne diseases. By the proper control of filtration with laboratory tests, plant effluents with a B. coli index of zero are becoming common. Secondary lime treatment for red water control has become standard practice, and prechlorination is being used in a number of plants to good advantage.

In one instance a technical operator worked out a treatment process for highly colored water. This process consisted of a primary dosage of chlorinated copperas and a secondary dosage of either sodium aluminate or alum and lime added simultaneously. Another technical operator, by the chlorination of coagulated water, increased the length of filter runs, lowered the cost of operation and turned out a better effluent.

Of the 78 municipal water-purification plants in the state, 63 are in small towns, and 28 of these plants are operated by technical men. Twelve of the fifteen plants in large towns are technically operated. Three out of five institutional plants are operated by technical men. One town with a population of 1,147 has a technical operator who serves as superintendent of water-works, sewers and sewage treatment.

* * *

Development of a Distribution System for Greater Detroit

By F. H. Stephenson

Engineer of Water System, Detroit, Mich.

THE Detroit water distribution system was serving a population of 1,371,500 in 1924, with an average daily supply of 184,000,000 gal. (184 m.g.d.). Studies previously made, including a continuous pitometer survey begun in 1919, indicated that between 1950 and 1960 there would be a total population of 3,500,000 occupying about 300 square miles. The plan for supplying this population, now being carried out, calls for new water-purification plants in the western and northeastern parts of the city in addition to improvements and expansions of the present plant, located near the eastern boundary.

About 50 lb. per square inch was assumed to be a satisfactory average pressure for the central part of the city and 25 lb. in the outlying districts, at times of maximum consumption. It was decided to control pressures by maintaining uniform readings at convenient points near the centers of each service district. The following values (pounds per square mile) were assumed as reasonable friction losses in the pipe system: minimum hour, 0.75; minimum day, 1.50; average day, 2.25; maximum day, 3.75; maximum hour, 5.50.

Four service areas were laid out covering about 280 square miles. The business district will be served from the present Water-Works Park plant at a relatively low pressure. The other areas will be served from the three stations, each station working on two pressures and each area served by two stations. The several services are connected at their boundaries, but are kept separate by closed and sealed valves. For service beyond these primary areas, booster stations will be required—one is already in operation. Several 1½-m.g.d. elevated steel storage tanks, which ordinarily are allowed to ride on the line, are already in use. At times of high consumption the tanks are filled in the late evening hours and the stored water is eased into the system during the hours of peak demand.

In the master plan for the development of what are now outlying sections, each square mile is to be bounded with a pipe of at least 12-in. diameter, and in the half-mile roads will be laid at least 8-in. pipe. Extra wide streets will have a pipe line on each side. In the intermediate streets 6-in. and 8-in. pipes are to be laid. In the older sections of the city advantage is being taken of street resurfacing or widening to remove old mains and replace them with larger ones.

Pumping Seepage Water From Wells for Irrigation

Deep Wells and Pumps to Relieve Waterlogged Land and Furnish a Supplemental Irrigation Supply

DRAINAGE of lands below and adjacent to irrigated areas has been made necessary in many cases by seepage of irrigation water which raises the level of groundwater in the lower land and injures the land by waterlogging. Deep ditches or tile drains are employed usually for such drainage, but pumping from deep wells has been tried to improve drainage and at the same time give a supply for further irrigation. At the annual meeting of the land reclamation section of the American Society of Agricultural Engineers this method was described by E. H. Neal, of the agricultural experiment station at Moscow, Idaho, from whose paper the following information is condensed.

It appears that the results of ditch and tile drainage have not been as great as was expected, the continual application of water to the higher areas overtaxing the natural and artificial drainage. If the excess underground water can be pumped to the surface at points where it can be utilized for irrigation, it will serve the double purpose of relieving the wet land and improving additional dry land, since the available original supply of irrigation water is definitely limited and must be used more efficiently if larger areas are to be served. This method has been employed in California and Arizona, using 12- to 18-in. wells cased with light steel which is perforated at the water-bearing stratum and sunk deep enough to reach the permanent groundwater level.

In the Boise River valley, in southwestern Idaho, an experimental installation of four wells includes two of the gravel-well type 18 in. in diameter, 100 and 133 ft. deep, and two of the stovepipe cased type, 12 and 18 in. in diameter, with depths of 146 and 132 ft. respectively. Each has a motor-driven deep-well pump. The first cost of such installations, with a drawdown of 35 to 45 ft. and a yield of 1,300 to 2,700 gal. per minute, is estimated at $4,000 to $6,000, or about $5 per acre-foot of water, with operating costs of 60 to 90c. per acre-foot. Depreciation and repairs of motor and pump would add only a few cents to this operating cost.

Experience has shown that on account of the varying character of the formations it is necessary to study each location to determine the proper size and depth of well for effective service. There is need for more observation wells and more complete observation of groundwater levels, but the Boise Valley installation indicates that 700 to 1,000 acres around each pump have been drained effectively. While the first cost of a pump-drainage system is considerably below that of an open-ditch system, the former involves the operating cost of the pumps. But this is offset by the value of the water for irrigation, since water removed by drains must usually run to waste. In addition, the pumping lowers the water table much further than is possible with ditches, even when artesian wells are drilled along these ditches.

In the areas served by the Boise River it is estimated that 150,000 to 200,000 acre-ft. of water can be obtained each year by pumping from wells, with the possibility of additional water in seasons of scarcity. More water is needed during the latter part of summer, when the stream supply is depleted, and the farmers in this valley are advocating the building of an additional reservoir. But Mr. Neal states that the present reservoirs have not always filled and that a new one would be filled in only about five years of each 30-year period. He considers that the cost of reservoir water would be much higher than for the pumped water. Furthermore, the water from deep wells contains a lower concentration of alkali salts than the surface drainage water. It is of interest to note that a drainage district in the Boise Valley has contracted to supply a local canal company with 7,000 acre-ft. of water each year for $1 per acre-foot and has started a pump-drainage development with twenty wells.

Abnormal Dry Season in Far West in 1929

The dry season of 1929 in the Far West was abnormally dry at each of 21 Weather Bureau stations scattered over the whole length of the Pacific Coast and as far inland as Pocatello, Idaho, and Winnemucca, Nev. At ten of the 21 stations the 1929 precipitation for July to December inclusive was below the minimum for all previous years of record, the records extending from 80 to 31 years, but with only two stations having records of less than 41 years. Details are given in the accompanying table, reprinted from an article in the *Monthly Weather Review* for November, 1929, by Edward H. Bowie, of the San Francisco Weather Bureau office. Mr. Bowie's article does not analyze the figures here given in his table but discusses at some length the factors affecting seasonal rainfall in the Far West.

LOW PRECIPITATION IN FAR WEST FOR 1929 SEASONAL PERIOD, JULY TO NOVEMBER, INCLUSIVE

Rainfall given in inches

All figures from *Monthly Weather Review*, November, 1929, except that last column has been added

	1929	Normal	Previous	Minimum	Length of Record Began	Length of Record Years
Seattle, Wash	3.58	10.97	3.56	1895	1891	39
Tacoma, Wash	2.47	13.02	5.63	1917	1878	52
Spokane, Wash	0.85	5.47	1.37	1917	1881	49
Tatoosh Island, Wash	15.46	27.82	15.13	1923	1884	46
North Head, Wash	4.83	18.19	8.96	1917	1878	52
Portland, Ore	2.56	12.45	4.11	1890	1871	59
Walla Walla, Wash	1.73	5.32	1.37	1890	1886	44
Lewiston, Idaho	1.22	4.81	1.06	1890	1878	52
Boise, Idaho	0.63	3.39	0.06	1868	1868	62
Pocatello, Idaho	3.56	4.56	2.00	1902	1899	31
Baker, Ore	0.82	3.77	1.23	1892	1889	41
Winnemucca, Nev	0.14	2.12	0.12	1880	1877	53
Reno, Nev	0.69	1.73	0.38	1915	1888	42
Eureka, Calif	0.22	8.81	1.00	1880	1878	52
Red Bluff, Calif	0.10	5.18	0.22	1880	1877	53
Sacramento, Calif	0.15	3.18	Trace	1850	1850	80
San Francisco, Calif	0.01	3.95	0.33	1890	1849	81
San Jose, Calif	Trace	2.53	0.10	1890	1874	56
Fresno, Calif	0.01	1.73	0.19	1893	1881	49
Los Angeles, Calif	0.32	2.08	0.06	1891	1877	53
San Diego, Calif	0.26	1.45	0.05	1894	1850	80

Mitigating Frost Action on Road Surfaces

Soils Most Subject to Frost Action—Effect of Unequal Thawing—Prevention by Sub-Bases—Prevention by Drains—Repairing Frost Heaves

REPAIRS of road surfaces damaged by frost action are a major task of every highway official operating in the zone of severe winter weather. Each year, as more roads are improved, the expenditure in road structure, preventive work and repair is greater. The damage done by frost ranges from slight bulges in the surface profile to the heaving and breaking of rigid pavements and the complete destruction of secondary surfaces. Many studies, some of them highly scientific, have been made of frost action. Virtually every state having continued freezing weather has developed practices for mitigating frost action and for repairing its damages. In the discussion which follows, the causes influencing frost action and the means employed to overcome its damaging effects are summarized after a comprehensive study by a committee having a personnel of exceptional ability and experience. —EDITOR.

FROST heaves can occur only where water is present. Moreover, this water must be supplied through small capillaries at fairly rapid rates to the growing crystals. Primarily, two materials possess these properties to any degree—silts and open-structure clays.

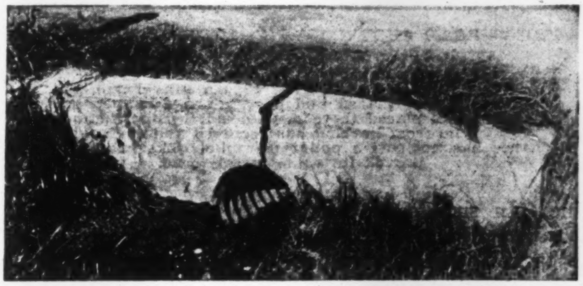


FIG. 1—EFFECT OF FROST HEAVE ON CULVERT IN NEW HAMPSHIRE

The pipe inlet opening allowed the frost to penetrate deeply into the ground under the pipe. The clay was damp and had capillary attraction and raised the pipe several inches higher than the ends of the plain concrete headwall, causing the wide break noted.

Due to the rapidity of capillary movement in silts and mica clays, frost heaving is more detrimental in these types than in heavy, colloidal, dense clays. In the latter, the extremely large particle surface area offers considerable resistance to the movement of water and hence its speed is lowered.

Surface Damage From Freezing—At the first freeze in a typical gravel highway on a capillary silt subgrade, such moisture as is present in the granular material freezes at about 30 or 32 deg. In this material no heaving or segregation is caused. The ice merely fills the large voids in the granular material and forms a solid soil and ice cake.

The moisture in the capillaries, however, does not freeze at this temperature and may not freeze while in the capillaries at abnormally low temperatures. The capillaries feed moisture from below to the already frozen granular ice cake at the surface, causing the formation of a layer of ice crystals growing vertically at the base of this ice cake. The crystals, in growing, exert a tremendous force and will lift any pavement. So far the action has been upward and the road is frozen quite solid. Rupture of macadams, cracking in concretes and the rolling of flexible types are caused by this action, if at all unequal, even without the effect of traffic.

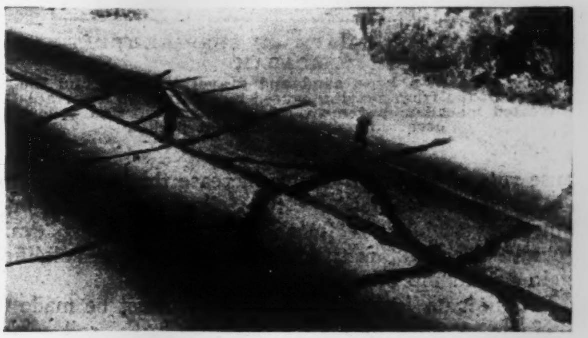


FIG. 2—CONCRETE PAVEMENT RUPTURED BY FROST HEAVE IN MICHIGAN

The slab is plain concrete of recent design with a doweled center joint. This slab heaves every year from 6 to 8 in., causing the excessive cracking noted. Tile drains have been installed, but proved ineffective.

Surface Damage From Thawing—However, the worst frost trouble occurs in the spring during a thaw. The center of the road usually has the least snow cover, is the most granular, gets the most traffic action and usually is the first part to thaw. Later, the quarter points melt and still later the shoulders, which are probably covered with snow. Thus the thawing line is a concave curve, and as the top area thaws, large volumes of water are liberated, but because of the frozen bowl below, the water is trapped and cannot escape down or to the sides, but exists as free water. When thawed, traffic moves over the supersaturated gravel crust, vibrating and crushing the soil into a soupy, mushy condition, wherein surface maintenance is of no value. Further freezes

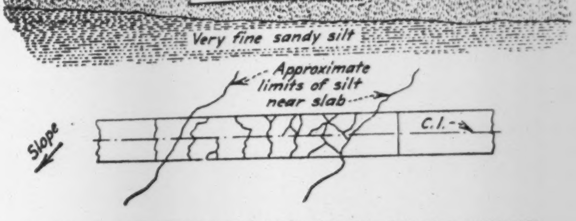


FIG. 3—SECTION AND PLAN OF FROST HEAVE SHOWN BY FIG. 2

The two upper strata were open drainable soil. The concrete slab rested on a coarse sand. The stratum immediately under the sand, however, was a very fine sandy silt, highly capillary and impossible to drain. This silt stratum was fed water from above and remained constantly damp. In warm weather the support was excellent, but in freezing weather the silt carried water upward at a fast rate, freezing and forming crystals at the bottom of the sand layer and causing detrimental heave and excess cracking in the concrete slab. It is noted that the stratum of silt crossed the road diagonally. Only where it was near the slab was unusual cracking noted.

Extract from the report of the committee on subgrades and pavement bases at the 1930 convention of the American Road Builders' Association.

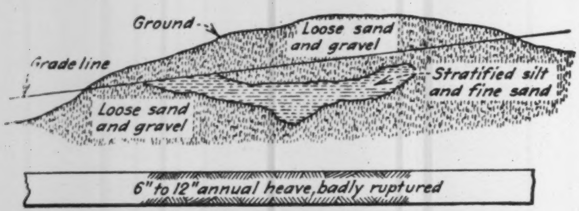

Ground
Loose sand and gravel
Grade line
Stratified silt and fine sand
Loose sand and gravel
6" to 12" annual heave, badly ruptured

FIG. 4—FROST HEAVE OF SURFACE-TREATED MACADAM

Silt pocket in a loose sand and gravel subgrade and the effect of the frost heaving caused by this silt on a surface-treated macadam pavement. It will be noted that failure occurred only over the silt pocket.

cause ruts, and further thaws increase this soupy condition, which exists until the thaw reaches the frost line, sometimes as late as May. Then the water can drain downward and allow the subgrade to become solidified again in a damp or dry state.

To eliminate frost heaving, attempt must be made to eliminate by some means the moisture in the soil, which causes the heaving. This moisture may originate from rain, seepage, condensation or free groundwater, but serious heaving is altogether due to water moving through capillaries. The first rule should be to keep the groundwater level low so that the capillary rise in cold weather will not reach the frost line. Deep ditches, preferably with perforated drains backfilled with porous material, are valuable for this purpose. It is indicated as especially advantageous to rid the soil of excess water of this nature just prior to the first serious freeze in the fall.

Granular Sub-Bases—Granular sub-bases, such as sand-gravel, sand-clay, stone and granulated or crushed slag, prove beneficial in certain instances. Their value lies in distributing the load over a greater area, equalizing the heaving and decreasing to the extent of their depth the amount of heaving and frost boils. Porous sub-bases should be adequately drained to the sides. Rhode Island, Massachusetts and other states in the Northeast have been very successful in overcoming heaving of the uniform type through the use of sub-bases. Rhode Island uses from 6 to 24 in. of 1½-in. to 20-mesh pit-run sand-gravel as a sub-base, with a 20-ft. width for an 18-ft. road.

The compact sub-base seems to exhibit the following benefits: (1) Eliminates capillary water movement for its depth and decreases the extent of heaving; (2) eliminates strata, pockets and laminated layers of unequally heaving material to the depth of sub-base and therefore tends to equalize heaving, decreasing detrimental action; (3) improves the uniformity of support; (4) decreases the depth of frost penetration by an amount equal to its thickness; and (5) provides increased load distribution.

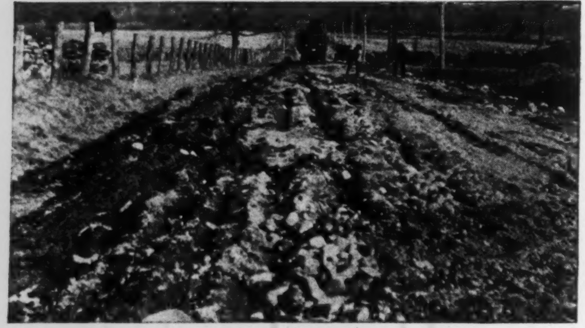


FIG. 5—A RHODE ISLAND MACADAM AFTER SPRING THAW

This picture was taken during the spring of 1923. The surface of the road was an old waterbound macadam without sub-base, on a silt subgrade. Heaving occurred every year at this point and the road became impassable to traffic.

Porous sub-bases, such as crushed stone, are valuable, but unless well drained may actually act as reservoirs for free thawed water and in this case will be detrimental.

A layer of sand between pavements and capillary subgrades, which does not extend in depth to the frost line, is productive of excess heaving in New Hampshire. Strata and pockets of other material in the subgrade profile cause extreme heaving as compared with adjacent sections and many even break concrete slabs irrespective of sub-bases when the latter do not extend to frost line. In such cases it has been deemed necessary to excavate troublesome subgrade to below frost line and to backfill with selected non-heaving or uniformly heaving materials.

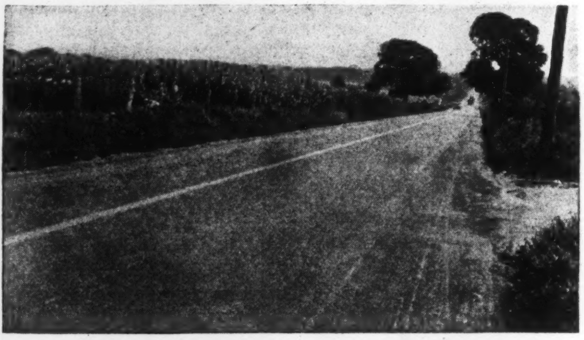


FIG. 6—ROAD SHOWN BY FIG. 5 AFTER RECEIVING SUB-BASE

This picture was taken at the same point as shown in Fig. 5 six years later. During 1923 a gravel sub-base of 12 to 21 in. was placed and a standard 8-in. penetration macadam was placed thereon. Since this construction, six years ago, no frost heaving has occurred and surface maintenance has not cost a dollar per mile. The sub-base has proved its value in this case.

Drains and Backfilled Trenches—Considerable study has been given to the treatment of frost boils in many Mid-Western states, and the benefits of these studies are becoming apparent. Among the treatments used in these sections are the following:

1. Trenches placed parallel to the center in ditch lines or shoulders and backfilled with porous material, and with and without tiles.
2. Trenches perpendicular or diagonal to the center, leading to suitable outlets at the roadside, backfilled with porous material, and with or without tiles.
3. Wide (8-ft.) and deep (4-ft.) trench under center line of road backfilled with porous material, drained by lead-off tiles.
4. Wide (20-ft.) and shallow (1-ft.) sub-base of crushed stone or gravel with ample tile outlets.
5. Complete excavation to frost line, insulation layer of tar or asphalt, backfilled to grade with some excavated material.

The success of the above-mentioned treatments have depended to a great extent on the conditions existing in each case, and it would be unwise to state that any one method is universally applicable. However, methods 3 and 4 (center trench, or variations) seem most likely to give general success.

Repairing Frost Heaves—Repairs to frost boils during the thawing season generally are aimed at getting

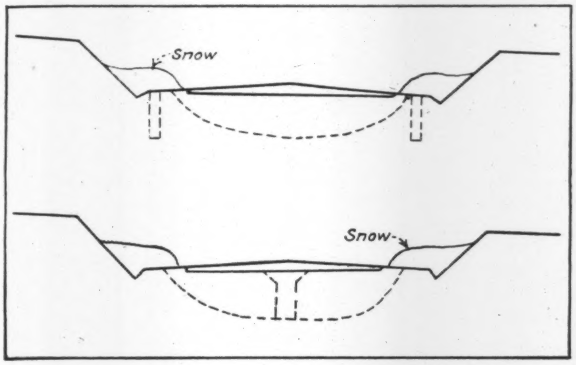


FIG. 7—DIAGRAM SIDE AND CENTER TRENCH INSTALLATIONS

Cross-sections of typical side drains and the center drain. The dotted line represents the approximate line of frost penetration. As the thaw begins in the center and moves downward in a concave curve, no water can reach the side drains until the thaw is complete. It must be remembered, further, that drainage through a capillary soil is very slow. In the lower cross-section the center trench serves to keep the roadway dry prior to freezing and is in a position to receive thawing water as fast as it forms. This type of drain is recommended in a capillary frost-heaving soil. If lateral water-movement occurs, the side drains would, of course, be beneficial.

rid of the water. Drains are installed, holes are blasted through the frozen layer to open strata below, steam jets are inserted in holes to thaw out a vertical drain, and other emergency measures are employed. It is a valuable practice to mark such situations for study during the summer. An ounce of prevention during the fall may prove worth a pound of repairs when traffic is tied up in the spring.

Collapsible Forms for Curved Sewers, West Side Sewage-Works, Chicago

A SIMPLE collapsible construction devised in building the West Side sewage-works of the Sanitary District of Chicago enabled complicated sewer forms to be re-used several times and permitted their removal in much less time than would be required for wrecking, with its small salvage of form lumber. One of these forms for a curved sewer connection is shown by Fig. 1.

Each form has interior frames composed of four segments in pairs, each pair being hinged together, as shown by Fig. 2. Lagging is spiked to the segments in the usual way. When set up, the two pairs of segments are separated by two key timbers or wedges the full length of the form, these being of tapered section and having their outer faces flush with the surface of the lagging. These keys are held in place by iron straps or short timber pieces, bolted to the segments, the whole form being then a rigid structure which can be handled by a crane or derrick. After the concrete has set, each strap is released at one end so that it swings away. In this way the keys are released and can be pulled in sidewise, allowing the form to collapse, the segments swinging inward (see Fig. 2) so that they can be removed intact. In small diameters the straps may be omitted, the key timbers being held in place by horizontal sticks placed across the form. These sticks and the key timbers can be pulled out with ropes, so that men need not enter to collapse the forms.

This collapsible construction was used on straight sewers 3 ft. in diameter and also on forms for long curved tubes 3 ft., 4½ ft. and 6 ft. in diameter, having single and double or S-shaped curves. These forms, about 50 ft. long, were built up on templets and made in lengths of 8 ft. to permit easy removal from the twisted concrete tube. The collapsible frames at the ends of adjacent 8-ft. lengths are bolted together (Fig. 2) to make a unit until the time comes to separate the lengths for removal. Some of these forms were used as many as ten times, with very little repair.

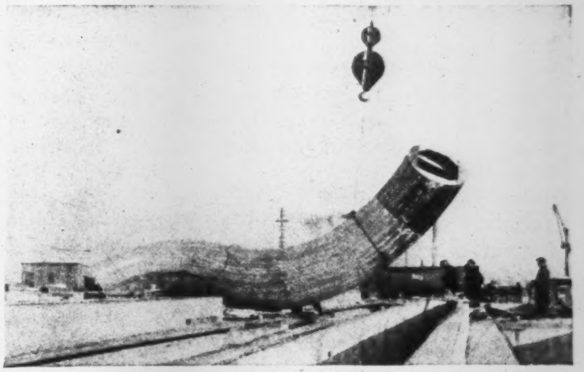


FIG. 1—A 50-FT. COLLAPSIBLE FORM MADE IN 8-FT. COUPLED SECTIONS

Another special construction consisted of forms for valve shafts and manholes, having a circular section at one end and a rectangular section at the other, so that the form had a tapered and warped surface. On the difficult work, removal was accomplished in about one-fifth or one-sixth the time required for wrecking, while on the straight sewer work the saving in time was even greater.

This design of collapsible form was developed on the job by Steve Swanson and John A. Dickerson, who at that time were carpenter foremen for the T. J. Forschner Contracting Co., Chicago, which had the contract for the sewage-works. It is now being handled by Steve Swanson, Berwyn, Ill.

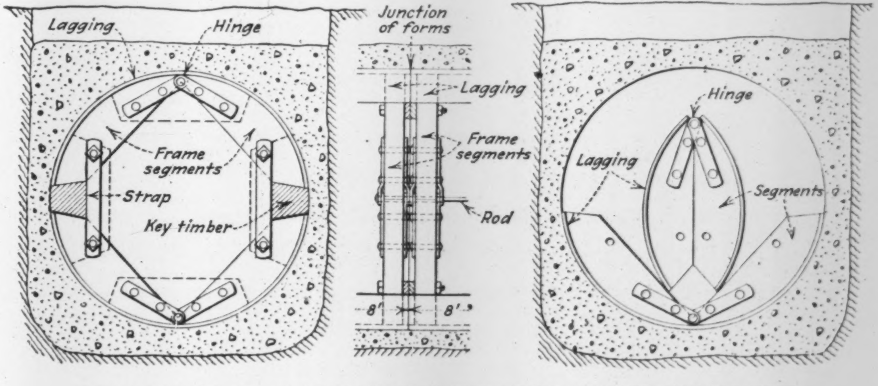


FIG. 2—DETAILS OF COLLAPSIBLE FORM FOR CONCRETE CONDUITS

At left—Form in place; dotted lines show wood braces sometimes used instead of the iron straps. At right—Form collapsed. Middle drawing shows connection of 8-ft. lengths of forms.

Engineering Literature

A Monthly Review of Books and a Listing of New Publications

Engineers on the Machine Age

TOWARD CIVILIZATION—Edited by Charles A. Beard, Editor of Whither Mankind. London, New York and Toronto: Longmans, Green & Co. Cloth; 6x8 in.; pp. 307. Decorations by E. E. Thurston. $3.

ROMANCE OF THE MACHINE—By Michael Pupin, Columbia University, Author of "From Immigrant to Inventor." New York and London: Charles Scribner's Sons. Cloth; 4½x7½ in.; pp. 111. $1.

THE recent output of books dealing with the machine age is almost overwhelming. Most of them are filled with questioning and protest. Some are almost despairingly pessimistic. Many lay the evils of the machine at the door of the engineer—with no attempt to define the engineer or to determine how and to what extent he is responsible. Few of these writers go into the program and status of civilization as a whole—and no wonder, when the subject is so vast and complex as to require not one but many writers to go far below the surface. A collaborative effort of the broader sort was Whither Mankind, recently brought out under the editorial guidance of Charles A. Beard, following closely after the Rise of American Civilization, by Mr. and Mrs. Beard.

In recognition of the fact that so many of the evils seen by writers on the machine age are laid at the door of the engineer, Mr. Beard conceived and executed the plan of having engineers and other scientists take up some of the many ramifications of the machine age from the vantage point of their own experience and observation. Supplementing his own acquaintance with that of several advisers, he chose twelve men and one woman, all widely known for their contributions to engineering and industrial progress, to produce the volume now under consideration: Toward Civilization—which is a sequel and answer to Whither Mankind. Together with the editor's Introduction and Summary, there are seventeen eminently readable and suggestive essays in the volume. Although each of the thirteen collaborators is known to all within and a multitude outside his own field, it does not seem enough to give their names alone here, so brief indication of their positions will be added. This is all the more desirable since, strangely enough, only the names are given in the book itself, a contributor's Who's Who appearing on the book jacket only—which most readers will soon discard. The topics treated, in their respective order in the book itself, are also given:

The New Age and the New Man: Ralph E. Flanders, manager, Jones & Lamson Machine Co.

Science Lights the Torch: Robert A. Millikan, director, Norman Bridge Laboratory of Physics, Pasadena; chairman, executive council, California Institute of Technology.

The Spirit of Invention in an Industrial Civilization: Elmer A. Sperry, chairman of the board, Sperry Gyroscope Co. [lately], president, American Society of Mechanical Engineers. [Died June 16, 1930.]

Power: C. F. Hirshfield, chief, research department, Detroit Edison Co.

Transportation: Roy V. Wright, managing editor, *Railway Age*; editor, *Railway Mechanical Engineering*.

Communication: Lee de Forest, inventor and producing engineer.

Modern Industry and Management: Dexter S. Kimball, dean of engineering, Cornell University.

Agriculture: Thomas D. Campbell, "proprietor of the largest individually owned farm in the world," located in Montana.

Engineering in Government: L. W. Wallace, executive secretary, American Engineering Council.

Art in the Market Place: Richard F. Bach, director industrial relations, Metropolitan Art Museum of New York.

The Machine and Architecture: Stephen F. Voorhees and Ralph T. Walker, of Voorhees, Gmelin & Walker, architects.

Work and Leisure: Mrs. Lillian M. Gilbreth, director, Gilbreth, Inc., consulting engineers and management.

Education and the New Age: William E. Wickenden, president, Case School of Applied Science.

Machine Industry and Idealism: Michael Pupin, professor of electromechanics, Columbia University.

Spirit and Culture Under the Machine: Harvey N. Davis, president, Stevens Institute of Technology.

Great pleasure as it would be to summarize each contribution to this valuable symposium, it is out of the question within the space available. The book itself should be read. Fortunately its low price makes ownership of the book within the purse of all, including beginners and students, for whom the book should be of great value in their formative years.

Some of the essays are chiefly categorical of the range and scope of activities in the field covered and some tend to the other extreme, but as a whole the book is to the point, which is that the engineer and the machine age alike are at least making toward civilization. That there is still a long way to go the authors agree. Some of them stress the part the engineer should take in lessening the acknowledged evils of the machine age; some point the way along the lines of increasing attention to the machine attendant, his family and the mass of humanity.

None of the authors brings out as clearly as he might, and as greatly needs to be done, that only a relatively small part of the evils of the machine age rests primarily with the engineer, the major part being chargeable to captains of industry, corporations and society at large. In the municipal field, for instance, the blame for much that is indiscriminately classed under the evils of the machine age rests upon councilmen and administrative officers, who say what the engineer may do, and upon the citizens as a whole, who do not insist that the engineers be induced or permitted to do what he stands ready to do for them. Mr. Beard points this out in commenting on his experience as adviser to the Japanese government after the earthquake and fire of 1923. He says:

> Two-thirds of the city was in ruins, leveled to the earth. A board of engineers, architects and city planners was commissioned to design a new city, combining technology and esthetics in a balanced picture. These leaders had at their command the lessons of the civilized world. They could design and build. The spirit of old Japan and a vision of the new age were in them. And with splendid enthusiasm they rose to meet the emergency and the opportunity. Whatever their limitations, if they could have had their way, they would have transformed the ancient city into a marvel of beauty and efficiency (for the two are not foes). Great work was accomplished, but not enough. And the failure in realization must be attributed to the esthetic and intellectual unpreparedness of the citizens rather than the desires of the technicians. The ground had not been sufficiently broken by the combined labors of physics and philosophy. Separated by tradition, they could not suddenly be united in a perfect harmony by a single crisis. Perhaps both parties were to blame for this state of affairs, but the technologists were more willing in spirit than the multitude whom they served.

Finally, in the closing words of his summary, where, it is significant to note, he substitutes "engineering age" for "machine age," Mr. Beard says:

> For the pitifully limited humanism of the fifteenth century, our

authors offer a humanism of science and engineering that has multiplied the powers of mankind to deal intelligently with human affairs far beyond the dreams of those who rescued the classics from the deadly grip of scholasticism. This is no "new" humanism, it is the old "system of thought and action," developed and applied with fearless imagination.

Imagination is the correct word. Science and engineering do not reject it and substitute mere logarithmic tables or routine mechanical procedure. Although our authors recognize the significance of that marvelous instrument of the modern mind—the invention of invention—although they rely upon it for making immense advances in the future, they still find that electric fluid, imagination, absolutely essential to the achievement of results in the realm of the unexplored and unprecedented. Without it, science and engineering become dogmatic and sterile. It must be and is being cultivated and nourished as one of the essential forces of the modern world. Imagination, informed by the known laws of nature, but unbound and free to experiment and dare, combined with the spirit of rationality, lives and flowers in the engineering age and will swing new planets into the ken of those who watch the heavens for signs of the future.

With equal tribute to the imagination of scientists, Michael Pupin, one of the contributors to Mr. Beard's symposium, has written a little book on the Romance of the Machine, which may well be noted here. Naturally, he takes up the telephone and the radio as great beneficiaries to mankind. He considers also the automobile and the airplane. All these, he eloquently and forcefully maintains, have greatly advanced civilization. He also ably comes to the defense, against the machine age protesters, of the abstract scientists. Besides all this, he shows in simple and telling language how, in bringing steam and the internal-combustion engine to the aid of man the engineer is merely reversing nature's own process by releasing energy stored through the centuries. The book can be read in an hour or so and with great mental profit—as would be expected by anyone who read Prof. Pupin's recent autobiography, From Immigrant to Inventor, noticed in these columns Nov. 15, 1923, p. 813.

Two Books in German

TRINK- UND NUTZWASSER in der deutschen Wirtschaft: In Beiträgen erster Mitarbeiter aus Wissenschaft und Praxis, Wirtschaft und Technik, den kommunalent Spitzenverbänden und wirtschaftlichen Organisationen—herausgegeben von Dr. Willi Vollbrecht, Direktor des Tarifvertragsamtes der Stadt Berlin und geschäftsführendem Vorstandsmitglied des Kommunalen Arbeitgeberverbandes Berlin, und Dr. Rich. Sternberg-Raasch, Geschäftsführendem Vorstandsmitglied des Reichsarbeitgeberverbandes Deutscher Gemeinde- und Kommunalverbande e.V., Stadtrat a.D. Berlin: Reimar Hobbing, S.W. 61. Cloth; 7x10 in.; pp. 302; 78 illustrations; tables. 18 marks.

DER WASSERBAU, II: Ein Handbuch für Studium und Praxis —von. Ing. Dr. Techn. Armin Schoklitsch, ord. Professor des Wasserbaues an der Deutschen Technischen Hochschule in Brünn. Zweiter Band. Wien: Julius Springer. Bound; 8x11 in.; pp. 1,199; 1,348 illustrations and 44 tables. 78 Rm.

WITHOUT any direct counterpart in our own literature, "Trink- und Nutzwasser" presents a semi-popular discussion of the many problems confronting the water-works engineer. Associated with Drs. Vollbrecht and Sternberg-Raasch in the presentation are twenty or more contributors, each a recognized authority on the specialty allotted to him for discussion.

The subject is treated in a very comprehensive manner, from a general description of natural characteristics possessed by surface supplies and groundwater, to a discussion of the social, economic and political aspects of its use by civilized communities. Purification processes are given rather scanty attention, but undoubtedly sufficient to achieve the book's purpose—to acquaint the layman with what lies behind his water faucet. There is a group of chapters on distribution, the fundamental hydraulics of pipe lines, measuring devices, plumbing fixtures, and equipment for sprinkling lawns and streets. Other chapter groups are devoted to water consumption, water hygiene and public baths.

An entirely different book is the second volume of Prof. Schoklitsch's "Der Wasserbau." It is a technical treatise of the highest order and more than fulfills the promise held out when the first volume appeared.

The subjects covered are dams and intakes, water-power plants, irrigation and drainage, river control and canal structures. In the first group are discussed the features of design and construction of fixed and movable dams, spillways and the entrances to headraces. The discussion is very complete and in so far as it is possible to do so in the space available covers the important features of all the many types of dams. Gravity types of both masonry and earthfill construction, arch dams, and hollow dams of slab and multiple-arch type, all come in for treatment. Movable dams and weirs are treated at length.

In the section devoted to power plants, after a short discussion of the general features of extracting energy from falling water, the headrace is first given attention. Next in order come penstocks and supply tunnels, surge tanks, forebays, screens, overflow weirs and energy-destroying devices. Hydraulic turbines come in for attention in the section on the power house, as does also the special equipment necessary for the operation of the plant.

These two subjects make up more than three-quarters of this volume, with the remainder of the space devoted to reclamation, river control and canal structures.

A veritable mine of information is contained in the 1,200 pp. of this volume. The binding, paper and typography are excellent, and there is not a page without illustrations.

French Portfolio of Diagrams

AIDE CALCUL GRAPHIQUE POUR LA MÉCHANIQUÉ GÉNÉRALE—Par Coloman Vargha, Ingénieur avec le Concours de l'Office National des Recherches Scientifiques Industrielles et des Inventions. Paris et Liége: Librairie Polytechnique Ch. Béranger. Boards, cloth back; 11½x16 in.; 21 folding plates loose in portfolio, including brief introductory text. 89.5 francs. francs.

THERE comes from France a series of diagrams, each approximately 22x15 in. in size, for the designing and checking of mechanical and structural details. Of the twenty charts, twelve treat of mechanical design, including such subjects as belts, shafts, gearing, friction clutches and springs. Of more interest to civil engineers are diagrams showing the force necessary to produce acceleration in a body, stresses produced in beams under either distributed or concentrated loads, and a series giving the weights of steel cylinders (both solid and hollow), bars, plates, and bolts and nuts. As the charts are not bound together, any one of them can easily be transferred to the drafting table. The metric system is used throughout.

Forestry on Water Company Lands

THE ELI WHITNEY FOREST: A Demonstration of Forestry Practice—By Ralph C. Hawley, Professor of Forestry, and William Maughan, Assistant in Applied Forestry, Yale University. New Haven: Yale University. Paper; 9x12 in.; pp. 46 plus 56 halftone plates, 3 folding maps, and tables. $1.50.

TEN tracts of land, acquired by the New Haven Water Co. to protect its water-collecting areas, are being handled for demonstration purposes by the Yale School of Forestry. The combined area of the tracts is about 20,000 acres. The whole area has been named the Eli Whitney forest after a Yale graduate of 1869, who, while president of the water company, initiated the land purchases and adopted "forestry as the best use of the watershed areas." This quarto pamphlet outlines the forest and the forestry work done for the company.

Folding maps and handsome large halftones show the various forested areas, improvement cuttings and portable sawmills. The hundreds of water boards and companies throughout the country that have gone more or less extensively into forestry, and the larger number that might well do so, would find this volume useful.

Timed Public Works and Business Cycles

PROSPERITY RESERVES OF PUBLIC WORKS—By Vernon Arthur Mund, Porter Ogden Jacobus Fellow, Department of Economics and Social Institutions, Princeton University. Philadelphia: American Academy of Political and Social Science. 6½x9½ in.; pp. 44; tables. Paper, 50c.; cloth, 75c.

WITH a view to the control of business depressions and unemployment much attention has been given of late to timed public works. The complete program, as some see it, means not merely speeding up construction in times of depression, with its complement of holding it in reserve, but also deliberate slackening of construction to prevent depression. In the study here under consideration the author briefly reviews the subject historically, including also rival theories of business cycles. Among other factors he considers the "velocity of money," or the number of its turnovers in a year, and the distribution of wages that would be paid out if in times of depression public works held in reserve were put under construction. He shows the need for better statistics of employment than now exist—few states of the Union even attempt to gather them. He assumes the necessity for state boards of control and for a like federal board, if timed public works are to be instituted. His concluding words are: "When the boards of control announce that the work should be started, the respective public work agencies would initiate their construction work in the usual manner. Thus the only new feature introduced is that a purposeful plan has been substituted for a haphazard plan of public construction work." The author uses the method of exposition rather than propaganda and weighs the many pros and cons of his subject. His study deserves widespread attention.

Present and Future of the Upper Colorado

UPPER COLORADO RIVER AND ITS UTILIZATION — By Robert Follansbee. Water Supply Paper 617, U. S. Geological Survey. Paper; 6x9 in.; pp. xv. + 394; halftone plates, folding maps and diagrams, line cuts in text and large map in pocket. 65c. from the Superintendent of Documents, Washington, D. C.

THE Upper Colorado River, above the Green River, has an area of 26,000 square miles, of which fully a sixth is in western Colorado and the remainder in Utah. It contains "hundreds of peaks" more than 13,000 ft. high and several "exceeding 14,000 ft.," west of which "these rugged mountains give way to flat-topped mesas in which the main river and its tributaries have deeply entrenched themselves in relatively narrow valleys." The volume noted above deals with the climate, evaporation, water supply, transmountain diversions (eastward), storage, irrigation, agriculture and water power of the vast area indicated. Nearly half of the 394 pp. are filled with streamflow records. A highly useful feature of the volume is a short synopsis of its contents. A brief preface is contributed by Nathan C. Grover, chief hydraulic engineer, U. S. Geological Survey. To follow is a similar document on the Green River. The two new papers supplement No. 395, on The Colorado, published in 1916, and No. 556, Water Power and Flood Control of Colorado River Below Green River, Utah, published in 1925, both by E. C. La Rue.

Co-ordinated Transportation

CO-ORDINATED MOTOR-RAIL-STEAMSHIP TRANSPORTATION—By G. Lloyd Wilson, Ph.D., Professor of Commerce and Transportation, Wharton School of Finance and Commerce, University of Pennsylvania; Author of "Traffic Management" and "Motor Traffic Management," and Co-author of "Principles of Transportation," etc. [Appleton's Transportation Series]. New York and London: D. Appleton & Co. Cloth; 5½x9 in.; pp. 228; illustrations and tables. $3.50.

A MAJOR transportation problem of today is that of co-ordinating the various forms of transport—ship, rail and motor—to form a unified system, and especially that of integrating the newest form—the motor vehicle—into the system in such a way that its full capabilities will be used to best advantage. Professor Wilson has made this subject the theme of this most recent addition to the Appleton transportation series. His thesis is that the public will be best served if each instrumentality of transportation is used in the service for which it is especially fitted and for which it is most efficient and economical, and that the determination of the part to be played by each must be ascertained by experiment, analysis and adjustment rather than on the basis of preconceived ideas and unsupported by experimental study.

Professor Wilson, in following out his own thesis, devotes the greater part of his book to a presentation of data regarding the work already done in this country to readjust our transportation system to the use of motor vehicles under various conditions in relation to rail and water transport; also to make the most of container cars and other modern developments. Few conclusions are drawn from these findings. They are used chiefly as a basis for outlining further lines of study and experiment.

Professor Wilson believes that the railroad companies should be permitted to use motor trucks and buses as extensively as seems desirable; and that any fears that in going into the motor vehicle operating field they will take over truck and bus lines only to stifle them are groundless. The railroads, he believes, are fully aware of the advantage of the motor vehicle over the railway car for many types of services and can be expected to use them to advantage if not checked by legislation. He also believes in interstate regulation of motor vehicles, as is done in the case of rail and water transport, to control wildcat operations and to provide for joint rates and to prevent the setting up of artificial rate barriers.

Ultimately Professor Wilson looks for a complete store-door delivery system in which the transportation company, either by its own trucks or by those of a contract carrier, will handle freight from origin to destination by whatever means is best suited to its most expeditious or most economical movement, either by motor truck, rail or ship, or by a combination of one or more of these.

Standards in the United States and Canada

AMERICAN STANDARDS YEAR BOOK, 1930—Paper; 8x11 in.; pp. 103. New York: American Standards Association, 29 W. 39th St.

CANADIAN ENGINEERING STANDARDS ASSOCIATION YEAR BOOK, 1929. Paper; 7½x10 in.; pp. 38. 178 Queen St., Ottawa, Canada.

PROGRESS in standardization as applied to engineering and industry is summarized in general terms and listed specifically in these two annuals. Examination of their contents discloses a range and volume of work that will surprise those who have not followed it closely. The American Standards Association "is a federation of 43 national bodies," initiated as a committee in 1918 by five major engineering societies. It has approved 166 standards and has 171 more under consideration. The present Canadian organization had its inception in 1917 and "acts as the advisory committee for Canada of the British Engineering Standards Association," which, the Canadian annual states, "was the first central body established for the work of engineering standardization, having been founded in 1901."

Publications Received

WHEELBARROWS of 23 types and varieties are included and pictured by sketches in Simplified Practice Recommendations, R105-29, U. S. Department of Commerce, Bureau of Standards. (10c. from Superintendent of Documents, Washington, D. C.)

ASSESSMENTS FOR BENEFITS to meet the cost of local improvements, as practiced in New York City, is the subject of a 60-p. quarto pamphlet by Charles W. Berry, comptroller (Municipal Building). Procedure is analyzed and changes are proposed to improve abuses that fall on the city and on property owners under the present system.

STREAMFLOW DATA—Its Collection and Use, a paper by H. B. Kinnison, district engineer, water resources branch, U. S. Geological Survey, together with discussion, fills 50 pp. of the May *Journal*, Boston Society of Civil Engineers. Many tables for New England streamflows are included. (50c. from Boston Society of Civil Engineers, Tremont Temple, Boston, Mass.)

BEET SUGAR WASTES TREATMENT, as studied experimentally during the 1927-28 and 1928-29 seasons by the British Water Pollution Research Board, is one of the main subjects of the report of the board for 1928-29. Waters from various processes at a factory were put through a detritus tank, revolving screen, mixing chamber, settling tank, percolating filter and humus tank.

HYDRAULICS is the first subject to be covered in Readings in the History of the Sciences and Engineering, issued in mimeographed form by Purdue University Library, Lafayette, Ind. The list on Hydraulics was compiled by Warren E. Howland, assistant professor of civil engineering, and William M. Hepburn, librarian. It is brief (4 pp.) and is offered merely as a "handy list of titles available" at Purdue.

ZONING LAWS AND ORDINANCES Adopted in 1928 and 1929 are summarized in a mimeographed bulletin by Norman K. Knauss published by the division of building and housing, Bureau of Standards, Washington, D. C. A list of cities adopting or amending ordinances in the two years named is included. Another bulletin, also by Mr. Knauss, reviews Zoning Legislation in the United States during the past 30 years. Similar to these bulletins is one on City Planning and Related Laws, by Lester G. Chase.

THREE PAPERS on Pumps and Turbines fill 54 pp. of *Technology Reports*, Tohoku Imperial University, Vol. IX, No. 2, 1930. Two of the papers are by Fukusaburo Numachi, and are on (1) the Hydraulic Efficiency of Propeller Turbines and Propeller Pumps, and (2) Two-Stage Propeller Pumps. The third paper, by Otogora Miyagi, is on Cavitation in and Consequent Vibration of the Draught Tube of a Water Turbine. The university named is located at Sendai, Japan, but those wishing to buy *Technology Reports* should address Moruzen Co., Ltd., at either Tokyo or Sendai. Unfortunately the price of the publication is not given.

New Books and Revised Editions

[*Those desiring copies of the books listed below or mentioned elsewhere in this section should order them from the publishers or from their local booksellers.*]

BACTERIOLOGY: A Textbook on Fundamentals—By Stanley Thomas, Professor of Bacteriology, Lehigh University. New York and London: McGraw-Hill Book Co. Cloth; 6x9 in.; pp. 301; frontispiece portrait of Louis Pasteur and 33 line cuts and halftones. $3.

BLUE BOOK OF SOUTHERN PROGRESS, 1930. Baltimore: Manufacturers Record Pub. Co. Paper; 6x9 in.; pp. 290; halftones, line cuts and tables. 50c.

Contains a large volume and variety of textual and tabular information on the resources, industries, and commerce of the Southern states.

BUS FACTS FOR 1930: A Publication of Facts and Figures of the Motor Bus Industry as of Jan. 1, 1930. Mills Building, Washington, D. C.: National Association of Motor Bus Operators. Paper; 6x9 in.; pp. 59; line cuts, tables and folding map.

THE DESIGN OF MASONRY STRUCTURES AND FOUNDATIONS—By Clement C. Williams, C.E., Dean of the College of Engineering, University of Iowa. Second Edition. New York: McGraw-Hill Book Co., Inc. Cloth; 6½x9¼ in.; pp. 596; halftones, line cuts and tables. $5.

New material in this edition, designed to cover progress since 1922, is given under concrete arch dams and foundations. An example of revision to give more satisfactory presentation is "a simpler and more practical analysis of retaining walls" in place of the "classic treatment of Coulomb." The size of the book has been increased by about 50 pp. The first edition was favorably reviewed in these columns Sept. 21, 1922, p. 487.

THE ELASTICITY OF CONCRETE—By H. H. Langdon. Pullman: State College of Washington, Engineering Experiment Station. Paper; 6x9¼ in.; pp. 45; line cuts and tables.

HANDBOOK OF LOCK-BAR STEEL PIPE—Compiled by East Jersey Pipe Co., 7 Dey St., New York. Imitation leather; 5x7½ in.; 240; halftones, line cuts, and tables.

A few pages describing the product indicated by the title and stating the advantages claimed for it are followed by many data, text and tabular, useful to designers of water pipe lines and distribution systems.

IRRIGATION PRACTICE AND WATER REQUIREMENTS FOR CROPS IN ALBERTA: (Revised Edition)—By W. H. Snelson, A.M.E.I.C., Senior Irrigation Specialist. Ottawa, Canada: Dominion Water Power & Reclamation Service. Paper; 6½x10 in.; pp. 84; line cuts, halftones, tables and a folding map.

MY LIFE WORK: Building and Metal Trades—By Robert L. Cooley, Director of Vocational Education, Milwaukee, Wis., Robert H. Rodgers, Chief, Division of Vocational Teacher Training and Research, and Harry S. Belman, Research Assistant, Division of Vocational Teacher Training and Research, Milwaukee Vocational School. New York: McGraw-Hill Book Co., Inc. Cloth; 6x8 in.; pp. 218; halftones. $1.75.

Brief popular illustrated accounts of the work of the carpenter, bricklayer, plumber, structural iron worker and other craftsmen in the building trades and of the draftsman, machinist, welder and others in the metal trades.

THE NEW INTERNATIONAL YEAR BOOK: A Compendium of the World's Progress for the Year 1929—Edited by Herbert Treadwell Wade. New York: Dodd, Mead & Co. Cloth; 7x10 in.; pp. 856; halftones, maps and tables.

The 28th issue of this annual follows the well-established and useful lines which make it a compendium of the year's activities and progress in hundreds of fields. Among the main subjects and contributors, often of groups of articles, are: Civil Engineering—James K. Finch, Professor of Civil Engineering, Columbia University; Electrical Engineering Subjects and Radio Communication—Walter I. Slichter, Professor of Electrical Engineering, Columbia University; Mineral Production—S. D. Strauss, Assistant Editor, *Engineering and Mining Journal;* Physics—Henry D. Hubbard, Secretary, United States Bureau of Standards; Power Engineering, Power Plants, etc.—Alfred D. Blake, Associate Editor, *Power; Railways*—William E. Hooper, Former Financial Editor, *Railway Age;* Sanitary Engineering and Municipal Subjects—M. N. Baker, Associate Editor, *Engineering News-Record.*

THE RADIO AMATEUR'S HANDBOOK: A Complete, Authentic and Informative Work on Radio Telegraphy and Telephony—By A. Frederick Collins. Sixth Edition. Revised by George C. Baxter Rowe. New York: Thomas Y. Crowell Co. Cloth; 5½x8 in.; pp. 368; 15 halftones, line cuts in text, tables. $2.

REMOVAL OF MILK CONSTITUENTS BY FILTRATION—By Max Levine, Bacteriologist, George W. Burke, Chemical Engineer, J. H. Watkins, Assistant Bacteriologist. Ames: Iowa Engineering Experiment Station. Paper; 6x9 in.; pp. 46; halftone, line cuts and tables.

An experimental lath filter operated at a rate of 0.8 m.g.d., but for ten to fourteen hours only on each day, indicated that such a filter is "a feasible means of partially treating creamery wastes so as to produce effluents which may be discharged into municipal sewage without danger of development of detrimental acidities in the municipal sewage-disposal plant."

SAND MOVEMENT AND BEACHES: Including References on Bars, Bays, Coast Changes, Currents, Erosion, Estuaries, Shorelines, Tides, Waves and Wave Action. With an Index. A Bibliography prepared under the direction of the Chief of Engineers, U. S. Army, by H. E. Haferkorn, Librarian, Engineer School Library, Army War College. Paper; 6x9 in.; pp. 114. Copies may be obtained from Engineer School Library, Army War College, D. C.

STREET LIGHTING PRACTICE—By Ward Harrison, Director of Engineering, Edison Lamp Works, O. F. Haas, Assistant General Manager, Atlantic Division, and Kirk M. Reid, Engineering Department Edison Lamp Works, National Lamp Works of General Electric Co., New York: McGraw-Hill Book Co., Inc. Cloth; 6x9½ in.; pp. 264; halftones, line cuts and tables. $3.50.

STUDIES OF THE EFFICIENCY OF WATER PURIFICATION PROCESSES: IV. Report on a Collective Survey of the Efficiency of a Selected Group of Municipal Water Purification Plants Located Along the Great Lakes—By Sanitary Engineer H. W. Streeter, United States Public Health Service. Public Health Bulletin No. 193. Paper; 6x9 in.; pp. 100; line cuts and tables. 20c. from the Superintendent of Documents, Washington, D. C.

A STUDY OF SLIP LINES, STRAIN LINES, AND CRACKS IN METALS UNDER REPEATED STRESS—By Herbert F. Moore, Research Professor of Engineering Materials, and Tibor Ver, Assistant Professor in the University of Technical Sciences, Budapest, Hungary. Urbana: Engineering Experiment Station, University of Illinois. Paper; 6x9 in.; pp. 62; 46 halftones and line cuts; 6 tables. 35c.

TENSION TESTS OF RIVETS—By Wilbur M. Wilson, Research Professor of Structural Engineering, and William A. Oliver, Instructor in Civil Engineering, Urbana, Engineering Experiment Station, University of Illinois. Paper; 6x9 in.; pp. 38; 10 line cuts and half-tones, 17 tables. 25c.

Letters to the Editor

Arizona Protests

Sir—In your issue of May 22, 1930, p. 833, you publish an article entitled "Obstructing a Great Work," in which you state that the governor of Arizona "made the preposterous charge of hasty action by the federal government in carrying the great project [Boulder dam] forward" and further on discuss Secretary Wilbur's reply, which you state is "full and conclusive." You further refer to "Arizona's consistent attempts to obstruct a great work with the sole objective of deriving fanciful royalties from the river's water resources."

On May 15 the governor of Arizona answered Secretary Wilbur's answer, but in your issue of May 29 no mention of this is made, although ample time had elapsed for you to be apprised of it and in which issue, in fact, you report a Los Angeles election held May 20.

Governor Phillips' answer shows that the strongest and most convincing statements in Secretary Wilbur's answer, and on which your conclusions are based, are untrue.

The attacks made on Arizona since the fight for the enactment of Boulder dam legislation was begun have likewise been based on falsehoods, and we regret to note that *Engineering News-Record* has done more than its share of the attacking.

The undersigned, engineers and readers of your magazine, deeply resent your lending the prestige of *Engineering News-Record* to the circulation of false propaganda against our state and its people and to the detriment of an early righteous solution of this problem. We believe that no good can come from an attitude such as you have held and that in continuing to hold it you only aggravate the situation of which you complain.

W. J. Jamieson,
City Engineer,
Phoenix.
F. N. Holmquist
B. E. Gilpin
J. Lee Chambers
Harry E. Jones,
Pres. Phoenix
Chapter, American
Association of Engineers.
F. J. O'Hara
James S. Hess
C. O. Gilliam
L. F. Ritz
Thomas Maddock
F. H. Flint

T. R. Neiswander
F. F. De Merse
Ed A. Johnson
H. C. Hatcher
Ralph Hoffman
J. S. Mills
Otto Kitchen
E. V. Miller
W. L. Pendleton
R. A. Walters
Howard S. Reed
Sheldon K. Baker
W. C. Lefebvre
James Girand
Donald C. Scott
R. S. Baker

J. H. Robinson
Barney R. Hodgin
W. Johannesen
C. C. Small
W. W. Lane
C. H. W. Smith
George B. Shaffer
H. D. Alexander
W. S. Johnson
D. M. Downey
Earl H. Parker
Burt Clingan
A. F. Harter
H. L. North
R. M. Wilkerson
Charles F. Willis

Phoenix, Ariz.,
June 5, 1930.

Ogden's Typhoid Outbreak

Sir—I note in your issue of Jan. 16, p. 95, an article on the Ogden typhoid outbreak. You evidently have not seen the full reports of this office on the situation, which are herewith inclosed; also the report of A. L. Dopmeyer of the U. S. Public Health Service, and the answer to the reports of Messrs. Greaves and Daines.

The city commissioners were not inclined to accept the findings of the state board of health and employed the above-mentioned gentlemen to make an independent investigation. Nothing has developed to change the opinion of the state board of health, as expressed in the reports. I may add that one of the commissioners who has charge of the Ogden water department brought an action for $100,000 damages against the Ogden *Standard Examiner* for charging him with responsibility for the outbreak. I also understand that damage suits have been brought against the city by persons sustaining deaths from typhoid fever in their families, alleging the contamination of the water supply as the cause of the disease.

T. B. Beatty,
State Health Commissioner.

Ogden, Utah,
Feb. 1, 1930.

In its issue of Aug. 16, 1929, p. 272, *Engineering News-Record* published its first account of this outbreak, based on the preliminary report of Mr. Beatty and the investigation of Mr. Dopmeyer, in which a contaminated water supply was held to be the cause. The second article, referred to by Mr. Beatty, was based on the reports of Messrs. Greaves and Daines, who held that an infected milk supply caused the epidemic. In a rejoinder by Dr. Beatty, there is renewed insistence upon the contamination of the water supply at the time of the outbreak. The rejoinder states that the only alleged positive evidences offered in support of the infected-milk theory were that all of the victims had eaten at a certain group of lunch counters having a common milk supply, and that at one of these counters a carrier was employed as a waiter. Reliable information indicates that the victims did not all use these lunch counters, says Dr. Beatty, and furthermore, the man referred to and all others employed at these places have been proved by blood and feces tests to be free from carrier symptoms.—Editor.

Building Codes and the Producers' Council

Sir—Our attention has been brought to an item appearing on p. 947 of your June 5 issue relating to the subject of building codes discussed at the annual meeting in Washington of the Producers' Council.

The item is in error in stating that several new sets of building codes were drawn and submitted in the hope that cities now revising their codes could be led to adopt these as an integral part of their system. No codes have been drawn by the Producers' Council, nor are any contemplated. The council has a committee which has been studying various standards which might be desirable for incorporation in new codes or codes now under revision, but beyond listing these standards no action has been taken by the committee, nor does the council contemplate the formulation of any codes incorporating these or other standards to be sponsored by the council or the American Institute of Architects.

New York City,
June 9, 1930.

F. S. Laurence,
Executive Secretary,
Producers' Council.

Stop Tornadoes by Reforesting

Sir—I have read your editorial "Tornado Study" in the May 8 issue. I have been through several of them, and my experience may help.

As you know, these storms commence out on the prairies of Kansas, Wyoming, Iowa and Nebraska, and travel eastward with a terrific velocity. I have been lifted off my feet by one of them. My first experience with a tornado was about 35 years ago, when such a storm, which came from the southwest about 8:30 one evening, hit the house I lived in, but luckily did not wreck it. The storm did not do much damage in our town, but it hit Joliet, Ill., that night at 9 and caused great loss there. In my next experience, about twelve years ago, I was lifted off my feet.

About eight years ago two men and I were painting a small cottage (I am a contracting painter). We just got the second coat of paint on and about 10 a.m. a tornado came up from the southwest. I told my men to get under cover. We were no more than settled when she came flying by. The house faced west; the rain and wind cleaned the front of that house as clean as a whistle; the north side wasn't scratched. The storm jumped on the top of a boiler works and never touched it. Between 1,800 and 2,000 ft. from the cottage I was painting is a large hill, 30 or 40 ft. high, on the edge of which stands a heavy growth of timber which runs back about a mile and a half. When the tornado hit the edge of that hill it burst.

This experience proves to me that heavy timber will aid nature in breaking up tornadoes. The government should reforest our open country, because it is the open country where tornadoes start. Reforesting would not only help to break up tornadoes before they got started doing much damage but would stop the floods caused by the heavy rain storms that we have been having in the last few years. On a good many of our farms there is more or less waste land that can not be cultivated which could be planted with acorn, hickory and walnut. Timber men should be made to plant a tree when they cut one down.

James W. Gregory.

Joliet, Ill.,
May 11, 1930.

News of the Week

Mississippi River Tributaries Get Control Allotments

Major Gen. Lytle Brown, Chief of Engineers, has made allotments from the appropriation of $35,000,000 for flood control of the Mississippi River and tributaries under the provisions of the flood-control act approved May 15, 1928. This act directs the secretary of war to prepare projects for flood control on all tributary streams of the Mississippi River system which are subject to destructive floods, with a view to ascertaining the effects of further flood control on the lower Mississippi which may be attained through the control of the floodwaters in the drainage basins of its tributaries by the establishment of a reservoir system. The allotments are as follows: Red River, $240,000; Yazoo River, $45,000; Ouachita River, $5,000; Big Black River, $5,000.

St. Francis Dam Disaster to Cost Los Angeles $7,000,000

Settlement of all but nine death claims out of more than 400 and of all demands for losses for personal property and property damages of all kinds arising out of the St. Francis dam disaster of March 13, 1928, has been announced. The cost to the city of Los Angeles will be about $7,000,000, which includes $1,000,000 used at the time of the disaster for relief work.

Indictments in Chicago Against Sanitary District Officials

Indictments have been found against ten persons, including five members of the board of trustees of the Chicago Sanitary District, charging them with conspiracy to defraud the district of amounts totaling $5,000,000. The charges include abuse of privileges in the construction of McCormick Boulevard, excessive expenditures on a $1,000,000 cinder path, and payroll padding in virtually every department of the district.

Memphis Gets Ninth Annual Asphalt Paving Conference

At a meeting of the board of directors of the Asphalt Institute, held in New York, Memphis, Tenn., was selected as the meeting place for the ninth annual Asphalt Paving Conference to be held Dec. 1 to 5. The Association of Asphalt Paving Technologists will, as usual, meet in conjunction with the conference.

State Officials to Discuss Distribution of Highway Funds

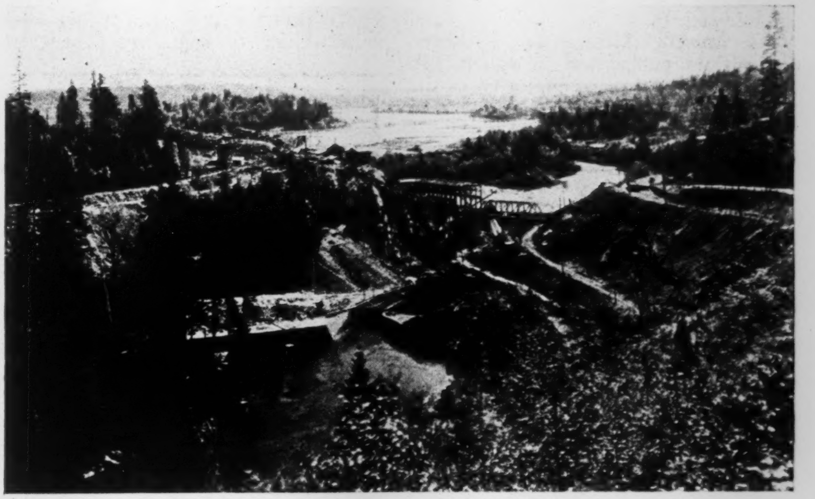
Distribution of highway funds between the state and county systems is one of the subjects which Samuel Eckels, president of the American Association of State Highway Officials, expects to bring before the annual meeting of the association in Pittsburgh in November. Studies now being made on that subject are expected to be in shape for presentation at the meeting so that an equitable division of funds can be made.

A large part of the time at the next meeting, it is Mr. Eckels' hope, will be devoted to proposals for the expansion of the work of eliminating dangerous spots and to the advancement of the scenic phase of highway construction.

The various studies that are in progress in connection with the effort to secure better enforcement of traffic regulations are well advanced.

Engineers Inspect All-Welded Building Completed in Newark

A party of about 250 engineers on June 14 inspected an all-welded building at Newark, N. J., erected by the Westinghouse Electric & Manufacturing Co. as a warehouse and service building. Although only two stories high, this structure is said to contain slightly more tonnage than any other all-welded building, and to present a typical example of present practice in welded structural building practice. The structure is L-shaped, 330x300 ft. in dimensions, with a height of 35 ft., or two stories. Roof trusses have 30- and 60-ft. spans. It is equipped with six cranes with capacities ranging from 1 to 15 tons, all of which are mounted on welded runways. The 1,060 tons of structural steel used was assembled in slightly more than two months. Field welding required 192 man-days exclusive of foremen and hoisting engineers. From one to six gasoline-driven welding machines were used. United Engineers & Constructors, Inc., of Newark, was the general contractor.



RUSKIN WATER-POWER DEVELOPMENT NEAR VANCOUVER

The water-power development by the British Columbia Electric Railway Co. at Ruskin, on the Stave River, near Vancouver, B. C., will eventually be one of the larger water-power projects in Canada. The first unit will have a capacity of 47,000 hp., and subsequently other units will be added until the ultimate capacity reaches 188,000 hp. The present development consists of a 184-ft. gravity dam, and tunnels (shown in the picture) leading directly to the penstocks supplying the 47,000-hp. unit. Lining of the tunnels with concrete is under way, and the steel for penstocks has been placed at the power plant end. It will be noted that the railway has been raised to a higher level, since the old track will be covered by the waters of what will eventually be a 700-acre lake in the foreground.

Nashville to Vote on $1,900,000 Bond Issues

The citizens of Nashville, Tenn., will vote on June 26 to accept or reject issues of bonds totaling $1,900,000. Five projects are involved, as follows: to acquire land and grounds for a municipal airport, $1,000,000; to construct an addition to the Nashville general hospital, $500,000; to purchase and install a steam turbine and generator unit and necessary auxiliaries in the city electric light plant, $100,000; contribution to the cost of the establishment of a President's plaza in Nashville, $150,000; to acquire site for, and to erect and equip a junior high school building to be situated in North Nashville, $150,000.

Highway Engineers of the A.E.F. Publish Regimental Paper

In order to hold together the group of 11,000 highway engineers who served in the 23d Engineers during the World War, a paper called the *Highwayman* is being published by members of the regiment. The 23d Engineers was recruited from the state highway departments throughout the whole country, partly through a campaign run in *Engineering News-Record* in space contributed by the publication and its advertisers. The regiment went to France with approximately 6,000 members; subsequently this strength was increased to more than 11,000.

The *Highwayman* is being published by Edward P. O'Day, 181 Highland Ave., Lowell, Mass. It is hoped through its publication to re-establish contact with the great majority of the members of the regiment whose present whereabouts are unknown.

Canvass of Construction Work Under Way by Census Bureau

Approximately 175,000 report blanks have been distributed in the census of construction canvass by the Bureau of the Census and it is the opinion of Alanson D. Morehouse, chief of the construction section, distribution division, that the number of contractors and builders who did at least $25,000 worth of construction work last year will range from 75,000 to 100,000. Although questionnaires were probably sent to contractors who did not do that much business last year, and many contractors were missed, it is expected that these errors will be eliminated by the personal canvass now under way. Until recently the canvass was conducted entirely by mail, but now in all cities of more than 10,000 population it has been turned over to the supervisors and enumerators for completion through personal visits. Both general and subcontracting work are included in the census.

Elmer A. Sperry Dies

Elmer A. Sperry, inventor of many mechanical and electrical appliances, died in the St. Johns Hospital, Brooklyn, N. Y., on June 16, following a long illness. Mr. Sperry's most notable invention was the gyro compass, now widely used in both aviation and navigation. His greatest contribution to the civil engineering field was a device for detecting the presence of transverse fissures in rails. Mr. Sperry was born in Cortland, N. Y. Oct. 12, 1860. He was educated at the State Normal School in Cortland and spent one year at Cornell University. His studies during this time had resulted in the invention of the first successful electric arc light and so in 1880 he went to Chicago to form the Sperry Electric Co. for the manufacture of arc lights, dynamos, motors and other electrical appliances.

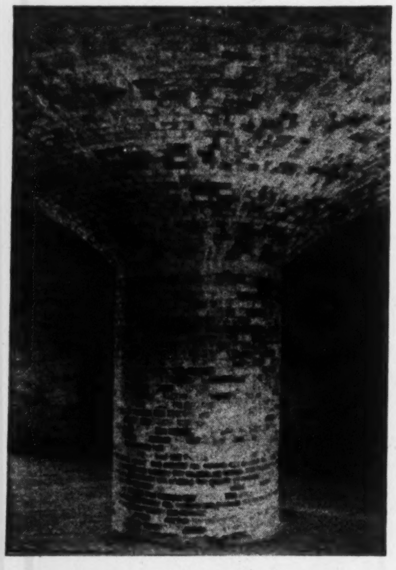
Mr. Sperry was one of the early pioneers in the development of automobiles in this country; he also gave considerable attention to electrochemistry.

About 30 years ago Mr. Sperry began giving attention to the possibility of the practical use of the gyroscope, then a scientific curiosity, and from his studies he developed the first successful gyro compass and the gyroscopic ship's stabilizer. In more recent years he developed the drift indicator and current indicator used in aviation.

Another important development credited to Mr. Sperry is the modern searchlight and from that the light widely used by the motion picture industry.

The development of the transverse fissure detector was one of his latest contributions to engineering progress. It has been in use only a few years but already has been highly successful in reducing the number of failures from that most baffling of all rail defects.

Mr. Sperry was one of the founders and charter members of the American Electrochemical Society and the American Institute of Electrical Engineers. He was past-president of the American Society of Mechanical Engineers and a member of many other technical and scientific organizations and the recipient of numerous awards and medals. Last year he took an active part in the organization and carrying out of the World Engineering Congress in Japan.



OLD BRICKWORK

An interesting example of well-preserved brickwork is afforded by this photograph of the Martello Tower in St. Johns, N. B., which was built about 1812.

Alameda Airport Enlarged

The area of the Curtiss-Alameda Airport, Alameda, Calif., has been more than doubled in the past four months by dredging sand from the Oakland-Alameda Estuary and piping it directly to the airport fill. Approximately 1,300,000 cu.yd. of sand has been piped in and when the development is completed, the airport will have an area of 343 acres with three cross-runways ranging in length from 3,000 to 4,000 ft.

Bids already have been received for the projected yacht harbor and seaplane base to be developed at this airport.

Surface oiling of the airport area now in use has been started to make the field dustproof and waterproof.

Court Validates Centralia's Power Development

In a unanimous decision dismissing the suit brought by a Centralia, Wash., taxpayer, the state supreme court has decreed that the city of Centralia may proceed with its hydro-electric power development project on the Nisqually River. After an election at which the voters approved a $650,000 bond issue to develop the project, the city commissioners spent $278,000. That election, however, was declared invalid by the supreme court because it had been irregularly advertised, and it was necessary to hold a second election, at which the bond issue was again approved by the voters. The court holds that the second election validated all prior action. The Nisqually plant, when completed, will have a capacity of 11,000 hp.

Portland Cement Case Dismissed

Because of lack of jurisdiction the Federal Trade Commission has dismissed its complaint charging the Portland Cement Association, its board of directors, officers and members with practicing unfair methods of competition. It had been charged that this association, composed of close to 100 manufacturers who make and sell about 95 per cent of the cement produced in this country, circulated statements disparaging to a method of cement road construction involving the use of vibrating machinery.

Colonel Pillsbury Nominated as Assistant Chief of Engineers

President Hoover on June 17 nominated Col. George B. Pillsbury to be assistant chief of engineers, succeeding Brig.-Gen. Herbert Deakyne, whose term will expire June 26. The position carries with it the rank of brigadier-general. Colonel Pillsbury received his professional education at Massachusetts Institute of Technology and the U. S. Military Academy at West Point, being commissioned in the Engineer Corps of the army in 1900. Since that date he has been, at various times, engineer member of the Alaskan Roads Commission, associate professor of mathematics at West Point, in charge of surveys on the Great Lakes, and attached to the St. Lawrence River Commission. At present he is district engineer at Philadelphia.

Chats Falls Hydro-Electric Power Project Progressing

Development work on the new hydro-electric power project at Chats Falls on the Ottawa River is actively proceeding. This will be one of the largest hydro stations in Canada, having an installation of 224,000 hp. Provision will also be made for later installation of two 28,000-hp. units, so that eventually the development will have a capacity of 280,000 hp. It is the joint undertaking of the Hydro-Electric Power Commission of Ontario and the Chats Falls Power Co., of Quebec.

To accomplish the development, a dam 3 miles long will be constructed. For about a mile of its length the dam will be an earthen section of low height. The remainder will be built of concrete and will have 72 sluiceways to discharge the floodwaters of the Ottawa River in time of freshets. The dam will follow closely the crests of the various chutes forming the Chats Falls, with foundations provided by the reef of Laurentian rock constituting this barrier in the Ottawa River. Between the falls and the widening of the Ottawa, about 3 miles above, the river falls about 13 ft. The total drop of the river along this section is nearly 50 ft.

Committee on Airport Drainage and Surfacing Organized

The technical resources of the American Engineering Council, the American Road Builders' Association and the aeronautics branch of the Department of Commerce, in so far as they relate to airport engineering and construction, have been joined to undertake the solution of the problems involved in adequate drainage and surfacing for airports. In announcing the formation of a committee to carry on the work, the aeronautics branch of the Department of Commerce states that the absence of uniform and thorough applications of adequate drainage and surfacing for airports has been responsible for accidents to planes in landing and taking off from airports and landing fields and for delays and interruptions in departures and arrivals of aircraft and has involved the waste of thousands of dollars in time and money in connection with airport or landing field projects. The membership of the committee is as follows:

Aeronautics branch, Department of Commerce—Harry H. Blee, director of aeronautic development, chairman; A. Pendleton Taliaferro, Jr., chief, airport section; John E. Sommers, airport specialist (secretary).

American Road Builders' Association—William A. VanDuzer, president, American Road Builders' Association and assistant chief engineer of the Pennsylvania highway department; C. N. Conner, executive engineer, American Roads Builders' Association; C. E. Myers, president, city officials division, American Road Builders' Association and director of transit, Philadelphia; Henry H. Wilson, member executive board of the Associated General Contractors division and managing partner of Winston Brothers Co. and H. H. Wilson, Harrisburg, Pa.; Charles M. Upham, engineer-director of the American Road Builders' Association and executive secretary of the manufacturers division.

American Engineering Council—W. W. Horner, chief engineer, sewers and paving, St. Louis, Mo.; Archibald Black, president, Black & Bigelow, Inc., air transport engineers, New York City; Perry A. Fellows, city engineer, Detroit, Mich.; C. A. Hogentogler, senior highway engineer, U. S. Bureau of Public Roads; James H. Polhemus, chief engineer and general manager, Port of Portland, Portland, Ore.

RANDOM LINES

Speed of Lightning

Storm vagaries comprised a 2-ft. snowfall in the western part of the state, *while on Cape Cod thunder and lightning, hurled along by a 70-mile an hour gale*, proved the other extreme. The barometer in Boston was 29.24 in. and the wind officially 28 miles an hour.—*Boston Herald.*

This reporter has stumbled on valuable scientific data relative to the acceleration of the velocity of lightning!

Per Cent and Degree Are Synonymous!

Did you every try to climb a 76 degree grade with your automobile? That's pretty near straight up—and if you don't believe it, set your watch at about 11 o'clock and the hour hand will angle upward at about the same slant as a 76 degree hill.

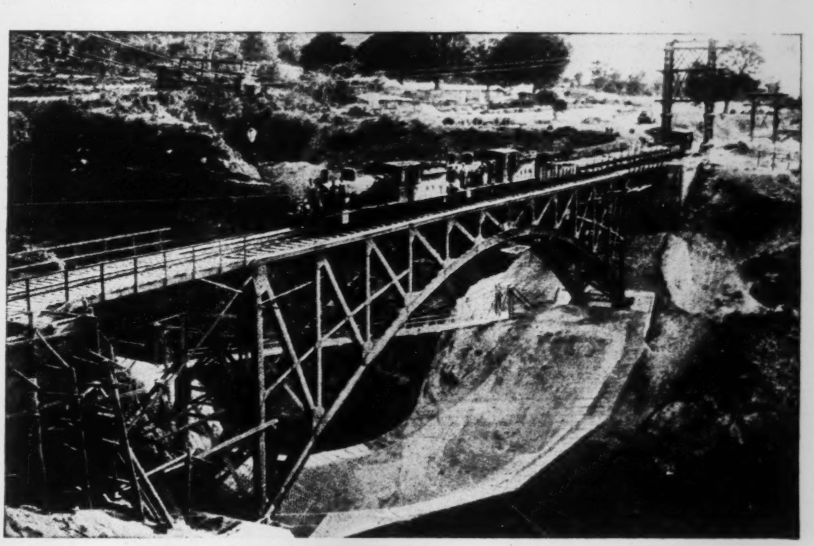
And, according to announcement here yesterday, a Chrysler-built Plymouth has just successfully climbed such a hill with power to spare.

The hill conquered by the sturdy Plymouth was the notorious Tice grade at Bakersfield. The hill is 840 ft. long. It has an average grade of 54 per cent, with a 76 per cent pitch at its steepest point.—*San Francisco Examiner.*

Another Professional Card

Cannon Engineering Company,
Jamaica, New York.

Its business will be unaffected by the outcome of the disarmament conference, because its representatives will be able to continue explaining "the unusual features of Cannon drape and shade fixtures."



STEEL ARCH RAILWAY BRIDGE IN INDIA

New bridge on the Kangra Valley line of the Northwestern Railway, India. Note the net slung under the arch, across the gorge, for the protection of workmen. Below and at the left is a highway suspension bridge. This view is reproduced from the annual report of the Railway Board, India.

Public Lands Problems Surveyed by Committee

Although the first meeting of President Hoover's committee on conservation and administration of the public domain was closed to the public, it is possible to indicate the trend of the proceedings. The score or more citizens from all parts of the country who came with their individual thoughts as to what should be done have gone away with a much less sure idea as to the ultimate national policy which should be shaped for the public lands but with a much broader concept of the problem and a real desire to study its elements before taking action. Despite the strongly sectional views held by some of the members, the proceedings were marked by a willingness to give and take and to reach a common agreement. The outstanding present fact is recognition of the magnitude and complexity of the problems affected.

One delegate pointed out that 50 million of the 200 million acres concerned are unsurveyed; that the continuing westward movement in the United States is significant; that Pacific trade has but begun; and that though much of the public domain is waste land at present, its future development cannot yet be foreseen. Present homestead laws are unsatisfactory, and the system evidently needs to be recast.

Questionnaire returns reflected the attitude of the several states as to whether land control should be retained by the federal government or ceded to the states. Although the answers were not made public, it is believed that Utah, Idaho and Oregon are inclined against taking over the land; Arizona, Montana and Wyoming favor; and Nevada, California and Washington are without a definite stand. It is obvious that, however amicable the committee, these sectional views are not going to be easy to iron out. Federal aid through reclamation, roads, mapping and the like gives a strong incentive toward the maintenance of the existing system, though perhaps the system is subject to some improvement. The states are by various means getting nearly all they could hope to gain through their tax systems and so will be inclined to fear anything that would jeopardize their funds from the federal government. This applies where the lands are relatively worthless from present standards; where there are reserves of known value there is an incentive toward local control.

Just how much transfer, if any, the committee will recommend is still purely speculative; possibly the forests will be retained, plus certain of the mineral and other reserves. It is believed that the administration is passing over its coal and oil problem for a committee opinion.

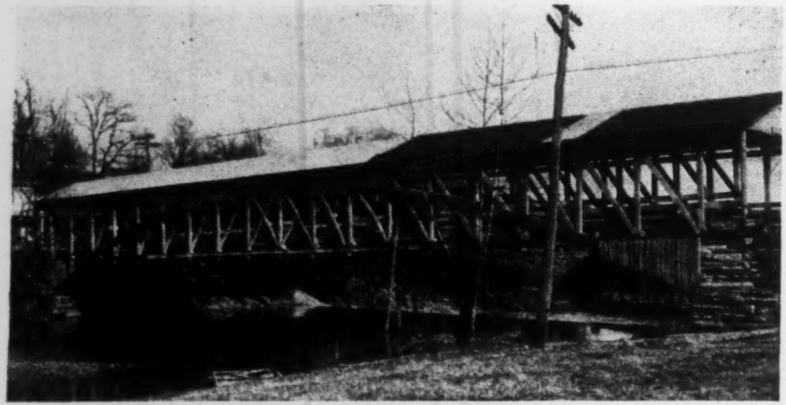
During the session little more was done than to hear the expert testimony of federal officials from the Reclamation Service, General Land Office, Geological Survey, National Park Service, Indian Office, Forest Service and the Interior Department oil committee. Party manners were preserved and bureau jealousies over land control were kept submerged for the occasion, but these, too, must be reckoned with in the final settlement. Adjournment was taken till next fall.

For a preliminary analysis of the problem, reference may be made to *Engineering News-Record* of July 25, 1929, p. 137, and Sept. 12, 1929, p. 427, which articles sketch the general situation.

The Business Outlook

Business appears to be undergoing a secondary relapse as the summer season progresses. Basic industrial activity is holding up fairly well for the season, but general trade is less active as the decline in commodity prices continues. *The Business Week's* preliminary index of general business activity has fallen to 90.5 of normal. This is the third successive week of decline and brings the index to the lowest point since the beginning of January.

—The Business Week, June 18.



OLD WOODEN BRIDGE CARRIES MODERN HIGHWAY TRAFFIC

One of the few remaining timber bridges on a main-line road is at Lexington, Va., where the Lee highway crosses the north branch of the James River. As pictured, the bridge is an all-timber Howe truss stiffened with wooden arch ribs and supported by abutments of stone masonry. It was built in 1872 to replace an earlier structure burned during the Civil War. The sheathing was recently removed to reduce the dead load.

Research to Control Consumptive Use of Water by Plants

Conferences on the consumptive use of water by plant life were recently held in Los Angeles and San Bernardino, Calif., under the auspices of the committee on contributions to groundwater supplies from rainfall and by spreading of streams, of the Los Angeles Section, Am.Soc.C.E. A. L. Sonderegger, consulting engineer, is chairman.

The conferences were held to discuss and determine the research work being done and that necessary to permit more complete control of consumptive use of water by plants. The average attendance at the conferences was about 100, and there were addresses and discussions by representatives of the division of agricultural engineering of the U. S. Department of Agriculture, U. S. Forest Service, California State Board of Forestry, faculty of the University of California, office of the state engineer, consulting engineers, foresters and agriculturists.

The work of the conferences was divided into three activities: (1) statements of research workers relative to the status of their investigations, their aims and purposes, and the methods applied; (2) statements by engineers, foresters and agriculturists as to the need of information for controlling the production and use of water by plant life; (3) formation of a permanent organization to stimulate research, to assist in securing funds for such research, and to act as a clearing house between research workers and practicing engineers and agriculturists.

The conferences developed that a great deal of experimental work is being done by the agriculturists and engineers of the U. S. Department of Agriculture and of the University of California. It was also learned that the California Forestry Experiment Station and the forestry division of the University of California are carrying on intensive experimental work in relation to influence of forest cover on run-off and erosion.

Resolutions were adopted favoring the formation of a permanent organization under the American Society of Civil Engineers and recommending that research work in the use of water by plant life, and consumption of rainfall be specifically included in the water resource studies of the State Department of Public Works, and by various federal agencies.

Use of Steel to Be Listed by Types of Construction

To determine the proportion of the structural steel output used in buildings, bridges, other heavy structures and light structural work, the Census Bureau, at the request of the American Institute of Steel Construction, is making a special survey covering 1928 and 1929. Although structural steel bookings and shipments are currently reported, no comprehensive information has been available on the type of construction in which this tonnage is used.

Brief News

Toledo's Union Railroad Station, which has served the city since 1886, was destroyed by fire on June 10. The city has been agitating for a new union station for more than 25 years.

The Hinged Arch will be employed in the design of London's new bridge to carry the Chertsey arterial road across the Thames at Richmond. The bridge will have five spans, three across the water and two over land, and will be of concrete throughout.

A Canal across the Strait Peninsula has been proposed to the Siamese government by a group of Danish, German and Dutch engineers. The length of the proposed canal would be 32 miles and its construction would shorten the distance from Ceylon to Hongkong from 3,040 to 2,430 miles.

New York's Eight-Hour Law applies to the building of the Conklingville dam (a part of the Hudson River Regulating District project), it has been decided by the Court of Appeals. The contractors claimed that the dam was a water-works construction and not a public work.

Construction of dwelling, office and industrial buildings in Germany shows a decline in 1929 of 11 per cent from the figures reached in 1928, and it is estimated that the 1930 figures will probably be 20 to 25 per cent below the figures of 1928. According to an official estimate, dwellings are 80,000 short of the existing demand, but lack of capital is making new house construction difficult.

Cleveland's $100,000,000 Union Terminal will be put into full operation on June 29. All but five of the New York Central and Big Four trains entering the city will after that date operate through the station.

Four Hydro-Electric Power Plants in Styria, a province in Austria, are under contemplation, and the promoters are negotiating in New York for a loan of $10,000,000 for their construction. The plan is for the government to contribute $1,000,000. An American commission will investigate the projects before deciding whether the loan will be granted.

WASHINGTON NOTES

By Paul Wooton

Washington Correspondent

Jadwin Plan Is Defended by General Jackson — Illinois Waterways Diversion Debated

In DEFENDING the Jadwin plan for the control of floods on the Mississippi and in attempting to justify the fuseplug type of levee, Gen. Thomas H. Jackson, president of the Mississippi River Commission, told the flood-control committee of the House of Representatives last week that there are few flood engineers in the United States other than those in the Corps of Engineers. Practically every witness who had preceded General Jackson on the stand had declined to indorse the fuseplug idea. The witnesses included the chief engineers of the railroads serving the lower valley.

General Jackson was particularly laudatory of the civilian engineers employed by the Mississippi River Commission. He referred to Col. Ernest Graves, of the Corps of Engineers, as the outstanding flood engineer of the world. He made special mention also of the ability of Roger McWhorter, of New Orleans. When asked if there were no outside engineers capable of passing judgment on the flood-control plan, General Jackson said he could recall at the moment only Arthur Morgan, who had worked out the flood-control plan for the Miami district.

General Jackson stated that he had had no part in formulating the Jadwin report but that he had recommended diversions as a means of flood control on the Mississippi in a special report made in 1913. He was entirely out of sympathy with the policy of the Mississippi River Commission of that day, which prescribed higher levees. It was his opinion that there could be little question as to the Jadwin plan being sounder than that of the Mississippi River Commission. The commission plan, he said, scarcely took care of the flood of the proportions of that of 1927.

More Revetment Urged

In his testimony, F. J. Jonah, chief engineer of the Frisco Lines, expressed the opinion that more revetment should be used on the river to protect railroad lines and other valuable property. This brought from General Jackson the comment that one-third of all the money that has been made available under the flood-control act has been spent for revetment. As revetment costs $350,000 a mile, there are many important places where that expenditure cannot be justified, when the cost of new levees of the larger grade and cross-section is only $175,000 a mile. In that connection General Brown stated that the greatest single problem in connection with the control of floods on the Mississippi is the development of a cheaper form of bank protection. He urged all civilian engineers to submit ideas to be studied at the research office of the Mississippi River Commission at Vicksburg. General Brown prefers to call it "research office" rather than "hydraulic laboratory." Mr. Jonah assured General Brown that the railroad engineers will co-operate.

A. F. Bliss, chief engineer of the Illinois Central, testified that the Jadwin plan would cost his railroad $13,600,000. He said no special benefits would accrue to the Illinois Central, as it had not suffered greatly from flood damage prior to 1927; in fact, there had been no interruption of service since 1892. He was emphatic in his opposition to the fuseplug levee on the ground that there would be uncertainty as to whether or not it would afford the protection expected.

Indorses Board of Review

Robert H. Ford, assistant chief engineer for the Rock Island, spoke highly of the proposal that a new board of review be created. P. S. Kirkpatrick, of the Gulf Coast lines, urged that the floodways be left open so that diversion would begin at bankfull stage.

R. W. Barnes, chief engineer of the Southern Pacific Lines, advocated sills at the head of the floodways so that the discharge would not begin until the stage was somewhat in excess of bankfull. He has great faith in reservoirs and thinks the silt problem can be handled without great difficulty. E. F. Mitchell, chief engineer of the Texas & Pacific, told the committee that there is no justification for making a floodway of the entire Atchafalaya Valley.

Rivers and Harbors Bill Strikes Snag

Passage of the rivers and harbors bill in the Senate is being delayed by filibuster tactics employed by lake state senators who object to the language authorizing the federal government to take over the Illinois waterway. The bill has been approved by the Senate as far as the section dealing with the Illinois waterway. One of the items that has been passed upon authorizes the government to construct levees around Lake Okeechobee in Florida for flood prevention. As approved by the Senate, the State of Florida is only required to contribute $2,000,000 toward the work. As the bill passed the House, a local contribution of $4,546,000 was required.

Senator Vandenberg, of Michigan, who is the acknowledged spokesman for the lake senators, has announced that he will support the Illinois waterway project if the senators supporting it will agree to a limitation of the diversion. Senator Blaine, of Wisconsin, who has joined with Senator Vandenberg in opposition to the lakes-to-the-gulf waterway, has proposed an amendment limiting the diversion to 1,500 sec.-ft. It is contended by the lake state senators that by accepting this limitation, the bill will not go counter to the ruling of the Supreme Court, which limits the diversion for sanitation to 1,500 sec.-ft.

There is a feeling on the part of some of the senators supporting the Illinois waterway that the limitation proposed by Senator Blaine will not seriously impair the project. Senator Deneen, of Illinois, however, has not indicated a willingness so far to accede to the limitation. Unless some agreement can be reached by the opposing sides the entire bill will be placed in danger.

Highways Across Public Lands

A bill to enable the Bureau of Public Roads to construct highways across the unreserved and unappropriated public lands in the United States was approved by the House on June 16. Appropriations made under this bill will be apportioned among the states having more than 5 per cent of their area in such lands. The report of the committee concludes by stating that if transcontinental roads are to be completed and if many approaches to forest reservations and parks are to be constructed, legislation of this character is absolutely necessary.

Public Building Projects in Washington

The second deficiency bill, introduced in the House last week, carries a grand total of $66,211,844. The bill, without making actual appropriations for the entire sum, authorizes contracts to be entered into for six major building projects in Washington, D. C., which eventually will cost $37,350,000. The projects and the limits of cost are: new Post Office Department building, $10,300,000; new Department of Labor building, $4,750,000; Interstate Commerce Commission building, $4,500,000; Department of Justice building, $10,000,000; Public Health Service Building, $865,000; connecting building between the Interstate Commerce and Labor buildings, $2,000,000. The bill also authorizes $3,000,000 for remodeling the State, War and Navy buildings.

Personal Notes

C. B. Hunt, highway engineer of the District of Columbia, has retired, his retirement to be effective July 1. He has been connected with the department for 33 years.

W. Curran Cavanagh, Jr., for the last 2½ years with the port of Seattle, engaged in the design of terminal facilities, is now located in Wenatchee, Wash., employed by the Stone & Webster Engineering Corporation on the construction of the Rock Island dam.

E. H. Dauchy has resigned his position as assistant engineer in the valuation bureau of the Missouri, Kansas & Texas Railroad in St. Louis, to become a member of the firm of Gould & Herrin, Inc., engineers and contractors, Denver, Colo.

Frank E. Lawrence, for the past eleven years secretary of the St. Louis (Mo.) city plan commission, has resigned to become assistant director of the civic development bureau of the St. Louis Chamber of Commerce. Don H. Morgan, former assistant engineer of the commission, has been named to fill the vacancy. For the past year Mr. Morgan has been assistant bridge engineer for the St. Louis-San Francisco Railway.

D. D. McGuire, formerly engineer of tests for the Tennessee highway department, has accepted the position of district engineer for the National Sand and Gravel Association, with offices in St. Louis, Mo.

Maurice B. Lagaard, for the past four years an associate engineer in the research laboratory of the Portland Cement Association, Chicago, has been appointed chief engineer of the Minneapolis Bridge Co., Minneapolis. Mr. Lagaard, a native of Minnesota and a graduate of the University of Minnesota (1915), formerly was assistant professor in the department of civil engineering of that university and was identified with many investigations in concrete and reinforced concrete from 1915 to 1926. During 1918 and 1919 he was connected with the investigations of the concrete ship section of the Emergency Fleet Corporation. In order to carry on the work for which Mr. Lagaard was responsible in the Portland Cement Association, the personnel of the research laboratory is being regrouped and T. C. Powers, of Salem, Ore., is being added to the staff.

The H. K. Ferguson Co., engineers and builders, Cleveland, Ohio, has acquired the business, assets and good will of Warren D. Spengler, Inc., consulting power plant engineers, of the same city.

A partnership to be known as Reeder, Eiser & Akers, consulting engineers, with offices in Baltimore, has been formed, consisting of Charles L. Reeder, John L. Eiser, H. Albert Akers, Henry S. Ostheim, William Hartman and M. M. Hamilton.

Society Calendar

AMERICAN SOCIETY FOR TESTING MATERIALS, Philadelphia; annual meeting, Atlantic City, N. J., June 23-27.

AMERICAN SOCIETY OF CIVIL ENGINEERS, New York; annual convention, Cleveland, Ohio, July 9-11.

AMERICAN WELDING SOCIETY, New York; fall meeting, Chicago, Sept. 22-27.

NATIONAL SAFETY CONGRESS, Chicago; annual meeting, Pittsburgh, Pa., Sept. 29-Oct. 3.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, Pittsburgh, Pa.; 38th annual meeting, Montreal, Canada, June 26-28.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS will meet at Minneapolis June 24-27.

NATIONAL BUILDING OWNERS AND MANAGERS ASSOCIATION, at its meeting in Biloxi, Miss., on June 12, elected the following officers: president, Charles F. Palmer, Atlanta, Ga.; vice-presidents, David Whitcomb, Seattle, Wash., Graham Aldis, Chicago, and C. J. Quinlan, New York; secretary-treasurer, Clarence M. Turley, St. Louis.

NATIONAL CONFERENCE ON CITY PLANNING will hold its 22d meeting in Denver, Colo., on June 23-26.

NEW YORK STATE ASSOCIATION OF CITY AND VILLAGE ENGINEERS met at Utica, N. Y., on June 9 and elected the following officers: president, M. W. Wipfler, Elmira; vice-president, G. Wallace Codwise, Kingston, N. Y.; secretary-treasurer, Joseph B. Shaw, city engineer of Utica. The next meeting will be held in Elmira in September.

NEW YORK STATE SECTION, American Water Works Association, will hold its meeting in Watertown in October. The exact dates and program have not yet been decided upon.

NEW YORK STATE SEWAGE WORKS ASSOCIATION will hold its fall meeting in Syracuse on Sept. 13 instead of Sept. 6 owing to a conflict in dates. A. S. Bedell, state department of health, Albany, is secretary-treasurer.

PACIFIC NORTHWEST SECTION, American Water Works Association, has elected officers as follows: chairman, Alex Lindsay, superintendent water department, Spokane, Wash.; vice-chairman, Carl A. McLain, general superintendent-secretary, Eugene water board, Eugene, Ore.; secretary-treasurer, Ernest C. Willard, consulting engineer, Portland, Ore. Owing to the fact that R. F. McLean, who was elected secretary-treasurer, declined to accept the office, the board of directors requested Mr. Willard to continue in the office for another year.

SMOKE PREVENTION ASSOCIATION will hold its annual meeting at Newark, N. J., June 23 to 26. The secretary is Frank A. Chambers, Chicago.

Obituary

Francis M. Dunn, contractor and former member of the Shelby-Dunn Construction Co., of Indianapolis, died recently in that city. Mr. Dunn, who was 82 years old, was born in Greenfield, Ind., and had lived in Indianapolis for 40 years.

Miles W. Birkett, vice-president and general manager, Washington Water Power Co., Spokane, with which company he had been since 1908, died on June 13. On May 17 Mr. Birkett was elected president of the Northwest Electric Light and Power Association for the term beginning July 1.

William Henry Harrison Weatherwax, chief of construction for the Panama-Pacific International Exposition, died on June 13 at his home in San Francisco. Mr. Weatherwax was actively connected with the construction of buildings for the world fairs in Chicago, Omaha, St. Louis, Buffalo, Norfolk, Va., and Philadelphia. He was 73 years old.

Alexander L. Greenabaum, vice-president of the O. F. Jordan Co. and for several years engineer on railroad and other construction work, died at his home in Chicago on June 4. He was born at Wilmington, N. C., in 1880, and beginning as a messenger boy on the Atlantic Coast Line Railroad he entered the engineering department and later served with contractors for hydro-electric plants and for lock and dam construction on the Ohio River. Mr. Greenabaum was engineer on a considerable portion of the Chicago track elevation work of the Rock Island Lines and then became supervisor of work equipment on that system. In 1920 he went to the Jordan company, manufacturer of railway spreader cars and ditchers. Mr. Greenabaum was a member of the American Railway Engineering Association.

Construction Equipment and Materials

Concrete Pavement Yardage

There is given below a tabulation of concrete pavement yardage awarded during the month of May, 1930, and also the total number of square yards awarded for roads, streets and alleys in the United States for the year 1930 to date as of May 31:

	Sq.Yd. Awarded During May, 1930	Sq.Yd. Awarded From Jan. 1, 1930, to May 31, 1930
Roads..........	14,898,957	51,131,994
Streets..........	3,818,236	12,741,954
Alleys..........	197,179	791,088
Totals.......	18,914,372	64,665,036

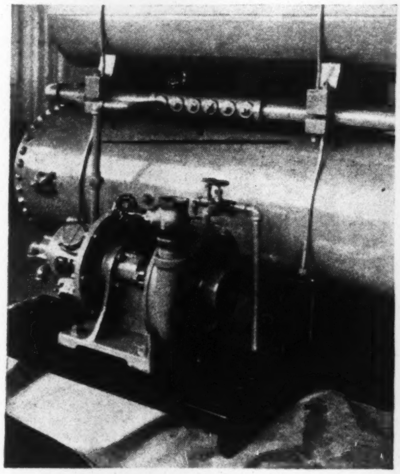
New Developments

Pump, Hoist and Grinder Driven by Compressed Air

Direct-connected air motors are used on three machines of special interest to contractors recently introduced by the Ingersoll-Rand Co., New York City. These include a small centrifugal pump, a bench grinder and a larger size of the Utility portable air hoist.

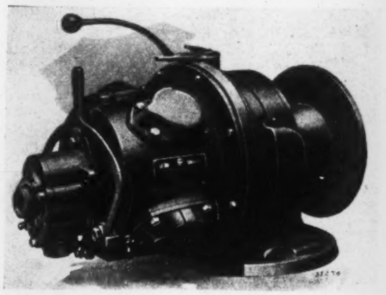
The pump is designed for mounting on a shelf at the rear of a portable air compressor, and should prove useful in dewatering trenches and excavations. It has a capacity, under 60 lb. air pressure, of 130 gal. per minute against a 29-ft. head. With 80 lb. pressure this is increased to 125 gal. per minute against a 43-ft. head. The pump itself is of the single-stage, single-suction, open-impeller, volute type and is driven by a four-cylinder air motor.

Many uses can be found on the usual construction job for the bench-type portable grinder, which has a free speed of 3,000 r.p.m. and is designed to take a vitrified grinding wheel 6 or 8 in. in diameter with a ½-in. face. At the end of the grinder spindle a bit chuck is provided to take a drill or reamer with a ½-in. straight shank. The air exhaust is directed through the base of the machine, a feature which prevents the grindings from being blown into the face of the operator. A steady-rest in front of the wheel aids the operator in holding the work.



PUMP ATTACHED TO AIR COMPRESSOR FRAME

Utility hoists, in capacities up to 1,500 lb., have been available for some time. The addition of the 2,000-lb. model makes this unit available for additional classes of work, such as hoisting buckets, pulling cars, skidding timbers and operating clamshell or orange-peel buckets. The comparatively light weight of the unit makes it easy to move directly to the job. The new hoist employs a radial, four-cylinder, counterbalanced, reciprocating-piston-type air motor which is reversible. Reduction gears between the motor and the drum are all machine-generated spur gears and are completely inclosed in a housing containing semi-fluid grease. Ball and roller bearings are used at several points. A clutch of the positive jaw type is used to disengage the motor, and a brake of the bank type surrounds the drum at its largest diameter.



AIR-OPERATED HOIST

Dual Purpose Served by Plug for Cast-Iron Water Pipe

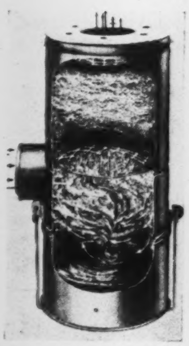
Greater economy in the laying of cast-iron water mains is secured by means of a new pipe end plug developed and patented by Harry W. Klinck, formerly superintendent of the water-works at Logansport, Ind., which is now being marketed in 6-, 8-, and 10-in. sizes by the H. W. Clark Co., Mattoon, Ill. Other sizes will be available soon. The test and puddle plug serves two purposes: It is inserted in the end of the pipe to retain water pressure for testing, and it provides for a pipe or hose connection to permit utilization of the testing water in puddling the backfill. During the test the pipe end is plugged securely by tightening a through bolt, thus expanding a gasket against the pipe wall. After the completion of the test, dirt is dumped into the trench a few feet behind the end of the pipe to form a dam, and a connection of 2-in. pipe or hose is coupled to the test plug to transfer the water to the trench behind this dam. This eliminates the necessity of tamping during the backfilling process. While the trench is being filled, the test and puddle plug may be removed to allow the laying of additional mains.

TEMPORARY PLUG FOR CAST-IRON PIPE

Air Cleaner Uses Oil to Catch Dust Particles

Three methods of removing dust from air—a vigorous centrifugal action, scrubbing through an oil spray and passing through an oily filter—are used in the air cleaner for internal combustion engines and air compressors developed by the Vortox Mfg. Co., Claremont, Calif. This consists of a chamber divided into two compartments separated by a baffle. The upper part is loosely filled with crimped wire, forming a metallic filter, and the lower consists of a removable cup containing light engine oil.

In operation, air enters a tangential inlet nozzle, causing a whirling action which draws up a certain amount of oil from the cup. The centrifugal action of the whirling air throws dust and oil particles outward against the walls of the cylinder, from which they wash the oil down into the cup. Much of the dust is also caught directly by the oil spray which fills the compartment. Small particles of foreign material which still remain in the air are caught by the metallic filter above, which does not act as a strainer but catches the dust, which adheres to the moist surfaces presented in the path of the air. The wires in the filter are washed by the oil spray thrown up from below, the excess oil carrying the dust with it to the bottom cup.

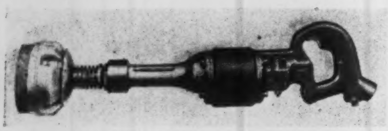


AIR FILTER

As there are no moving parts, the cleaner will last indefinitely without replacement of parts. The only maintenance necessary is the periodic removal of the dirt which collects in the bottom of the cup, and the replacement of oil at the same time. Any grade of light engine oil, including used crankcase oil, is suitable but the latter must be changed more frequently.

Pneumatic Tool Smooths Concrete

For finishing and smoothing concrete and also for working on marble, granite and similar material, the Chicago Pneumatic Tool Co., New York City, has announced the model 88 rotary concrete surfacer. This tool has a series of four vanes which rotate on a spindle in a casing. It can be equipped with a cutting head attachment, a buffer or a Berg surfacer. Non-vibrating governor control is used, with a heavy-duty radial and thrust ball bearing on the wheel end. The rotor is mounted on an overcapacity ball bearing. Lubrication is by means of an automatic oiler with grease plugs in the handle and the gear case end.



ROTARY CONCRETE SURFACER

Electric Power Generated by Portable Plant

Current for operating small tools or lights on isolated jobs which do not justify setting up a special generating plant can be supplied by means of a special motor-generator set developed by the Fuller & Johnson Mfg. Co., Madison, Wis., in two standard sizes, 1½ and 3 kw. Each set consists of a 115-volt d.c. compound-wound generator direct-connected to a gasoline motor, the smaller unit using a two-cylinder, 3-5-hp. engine, the larger, a four-cylinder, 6-10-hp. In both cases ignition is by means of high tension rotary magneto and lubrication by the circulating splash system. Thermo-syphon cooling is used. Weights of the two plants are 650 and 735 lb., respectively.

ENGINE-GENERATOR UNIT MOUNTED ON AUTOMOBILE

Costs and Contracts

E. N.-R. Index Numbers

Cost		Volume	
June 1, 1930	**203.36**	**May, 1930**	**354**
May 1, 1930	205.86	April, 1930	320*
June 1, 1929	205.65	May, 1929	395
Average, 1929	207.02	Average, 1929	317
Average, 1928	206.78	Average, 1928	287
1913	100.00	1913	100

*Revised.

This Week's Contracts

Heavy construction contracts, reported by *Engineering News-Record* in the week of June 19, with some comparisons, total as follows:

(In Thousands of Dollars)

Buildings:	June 19, 1930	Average Four Weeks 1930	Preceding 1929
Industrial	$6,876	$8,630	$11,154
Other	40,160	20,609	44,437
Streets and roads.	12,980	18,831	17,961
Other eng. constr..	10,250	30,491	12,367
Total	$70,266	$86,852	$85,920

Total, all classes, Jan. 1 to June 19:

1930	$1,779,256
1929	2,178,130

New Publications

Sheet Steel — Open-hearth sheet-steel products of the INLAND STEEL Co., Chicago, Ill., are described in a booklet recently issued by this company. Separate leaflets give details in regard to Gal-Van-Alloy steel sheets and copper alloy steel sheets.

Batching Equipment—Portable bins and Agrabatchers for proportioning concrete are described in a 16-p. loose-leaf circular of the HELTZEL STEEL FORM & IRON Co., Warren, Ohio.

Rock Crushers—Typical quarry plant designs to assist operators in selecting a type of plant best suited to their requirements are assembled in a 16-p. illustrated booklet produced by the SMITH ENGINEERING WORKS, Milwaukee, Wis. Advantages and disadvantages of the different plant layouts are discussed at length, and lists of the necessary equipment and the power requirements for each type of plant are given.

Safety—Methods of inciting employee interest in safety by stimulating the spirit of friendly competition are discussed in the seventh of the series of industrial safety leaflets issued by the Policyholders Service Bureau of the METROPOLITAN LIFE INSURANCE Co., New York City.

Welding—Arc-welding data bulletins 12 and 13 of the WESTINGHOUSE ELECTRIC & MFG. Co., East Pittsburgh, Pa., give methods of estimating the cost of arc-welded steel structures and a discussion of arc-welded jigs and fixtures.

Water Treatment—"The Ammonia-Chlorine Treatment of Water," a 22-p. bulletin issued by the NATIONAL AMMONIA Co., INC., Philadelphia, Pa., contains a discussion of this type of water treatment with results of tests, both laboratory and on a practical scale, which have been made by various scientists. A bibliography is included.

Steel Pipe—Many data on the design and construction of steel pipe lines, as well as considerable information on water-works practice and miscellaneous information on the subject of hydraulics, are contained in a 240-p. "Handbook of Lock Bar Steel Pipe," reissued in a new edition by the EAST JERSEY PIPE Co., New York City.

Trucks—Hauling experiences of contractors and roadbuilders in many parts of the world are related in a 12-p. illustrated booklet now being distributed by the DODGE BROTHERS CORP., Detroit, Mich.

Alloy Steels—"Alloy Steels in the Railroad Field," a reprint of a paper delivered before the railroad division, A.S.M.E., by Charles McKnight, has been published in 12-p. booklet form by the INTERNATIONAL NICKEL Co., INC., New York City. The paper discusses the increase in strength with decrease of weight obtainable by use of alloy steel for railroad forgin castings and boiler plate; the comparati physical properties of alloy and carb steels in such applications and the adv ability of using each from a standpoint economical operation. Corrosion-resisti material, nitriding and miscellaneous d velopments are also treated briefly.

Wheelbarrows—A number of types Speedbarrows for various uses are d scribed in a leaflet recently issued by t GENERAL WHEELBARROW Co., Clevelan Ohio.

Reinforcing Steel—Bar cards showi new standard billing weights for reinfor ing steel are being distributed by the Co CRETE REINFORCING STEEL INSTITUTE, Ch cago, Ill.

Steel Joists—The Kalmantruss joist, a open-web steel joist manufactured in on piece by a rolling and expanding process is thoroughly described in a new 20-p illustrated booklet issued by the KALMA STEEL Co., Chicago, Ill. A number tables are included giving safe loads an dimensions.

Cast-Iron Pipe—"Along Large Cast-Iron Lines," an illustrated book issued by th UNITED STATES PIPE & FOUNDRY Co., Burlington, N. J., describes several unusual pipe laying jobs in which cast-iron pipes were used. The series includes lines in Albany, Chicago, Portland (Me.), Louisville, Dallas, Milwaukee and Atlanta.

Pumps—Horizontally split case centrifugal pumps, of both the single-stage and multi-stage type, are described in a 12-p. illustrated bulletin issued by YEOMANS BROS. Co., Chicago, Ill.

Crawler Mountings — Trackson crawler wheels for mounting on heavy equipment are described in an 8-p. circular of the TRACKSON Co., Milwaukee, Wis.

Business Notes

RULES OF BUSINESS PRACTICE adopted by the structural clay tile industry at a trade practice conference held March 31, 1930, in St. Louis, Mo., have been acted upon by the Federal Trade Commission. Ten rules were affirmatively approved as condemning unfair methods of competition, and a number of others were accepted as expressions of the trade.

BRISTOL Co., Waterbury, Conn., has been granted a manufacturing and selling license by the Dardelet Threadlock Corp. under its patents for self-locking screw threads.

EUCLID CRANE & HOIST Co., Euclid, Ohio, has appointed Wilson G. Fleming manager of sales. Mr. Fleming's past experience includes service with the Drott Tractor Co. and the Hi-Way Service Corporation, both of Milwaukee.

BYRON JACKSON Co., Berkeley, Calif., has discontinued its San Francisco office.

BLAW-KNOX Co., Pittsburgh, Pa., announces that William E. Balliet has succeeded P. V. Kelly as manager of the Birmingham, Ala., office. Joseph Riley will become assistant manager of the district.

HERCULES MOTORS CORP., Canton, Ohio, has opened a new office in Tulsa, Okla., R. J. Scott, Mid-Continent sales representative, will use this as headquarters. Walter F. Radtke, who formerly represented Hercules is the Mid-Continent states, has been appointed Pacific Coast sales representative, with headquarters in San Francisco, Calif.

BRADFORD PUMP MANUFACTURING Co., San Jose, Calif., has appointed Eck L. Baughn sales manager. Mr. Baughn was formerly San Francisco district manager for the Byron Jackson Pump Co.

MASONITE-PRESDWOOD CORP., Chicago, Ill., has made the following appointments: E. L. Saberson, assistant sales manager in charge of all dealers' sales; E. B. Bushnell, head of the concrete forms department; and J. T. Card, industrial sales manager.

BROWN INSTRUMENT Co., Philadelphia, Pa., has awarded a contract for building two additional floors on all of the new two-story concrete sections of its plant. This will provide 40,000 sq.ft. of additional floor space.

INDEPENDENT PNEUMATIC TOOL Co., Chicago, Ill., has purchased the Cochise Rock Drill Mfg. Co., Los Angeles, Calif., which will operate as a unit of the Independent company. There will be no change in personnel or methods. The plant of the Cochise company will be expended and its products will be incorporated in the present line of the Independent company.

Unit Prices From Current Construction Bids

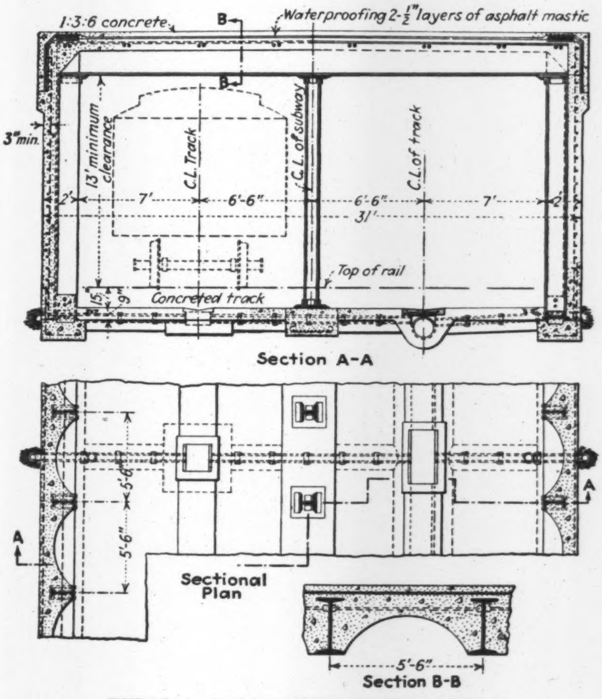
Grading and Gravel-or-Stone Surfacing, California

THE California Department of Public Works opened bids March 5, 1930, and awarded contract for 1.4 miles grading and surfacing with untreated crushed gravel or stone in Humboldt County. Nine contractors averaged 48.5c. on the excavation, which amounts to 63 per cent of the total cost. The corrugated pipe (1,098 ft.) is furnished by the state. Unit prices are given for the lowest three bidders: (A) Chigris & Sutsos, San Francisco (contract); (B) Kennedy-Bayles Construction Có., Oakland; (C) E. C. Coats, Sacramento.

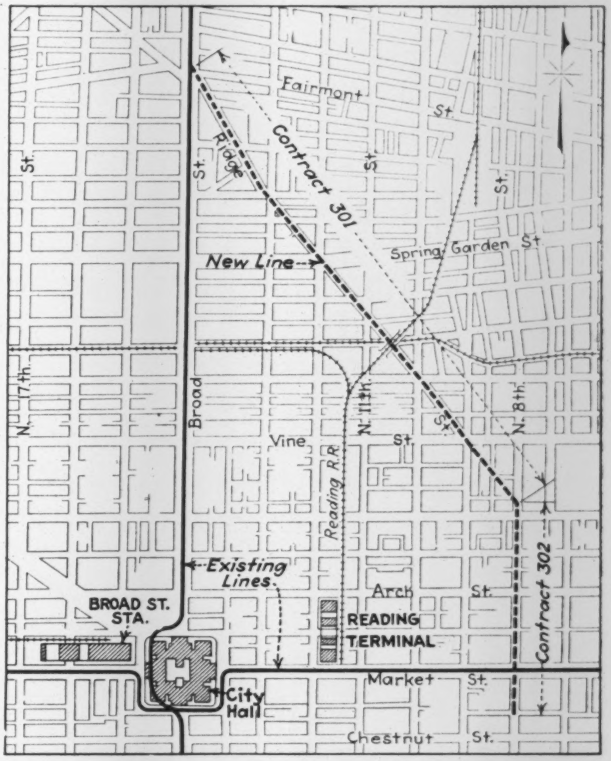
		A	B	C
Clearing and grubbing, acre	12	$250.00	$150.00	$250.00
Roadway excav. unclass., cu.yd	82,000	0.38	0.46	0.45
Overhaul, sta.yd	119,200	0.01	0.02	0.01
Structure excav., cu.yd	680	1.00	1.25	1.00
Untreated crushed gravel or stone surfacing, cu.yd	4,050	2.40	2.00	2.40
Water on surfacing, M gal	300	2.50	2.00	2.50
Screenings in stock-piles, cu.yd	720	2.55	2.00	2.40
Bar reinf. steel (structures), lb	5,350	0.06	0.06	0.06
Placing:				
12 in. corr. metal pipe, lin.ft	72	0.50	0.65	0.75
18 in. corr. metal pipe, lin.ft	782	0.60	0.75	1.00
30 in. corr. metal pipe, lin.ft	84	1.00	1.00	1.50
36 in. corr. metal pipe, lin.ft	160	1.50	1.50	2.00
Laminated timber, guardrail, lin.ft	1,000	1.00	1.00	1.10
Finish roadway, sta	73	5.00	5.00	5.00
Monuments in place	29	2.50	3.00	3.00
Totals		$52,551	$57,574	$58,815

Subway in Philadelphia

AT THE end of 1929 the Philadelphia Department of City Transit awarded Contract 302 to the Henry W. Horst Co. for a subway section in Eighth St. between Ridge Ave. and Ranstead St. for $2,592,937. The unit prices were published in the Jan. 23, 1930, issue of *Engineering News-Record*. Contract 301 was awarded in April, 1930, to J. & R. Lombardi for 4,565 ft. of two-track subway in Ridge Ave. extending approximately from Eighth St. and connecting with the existing subway in Broad St. This section includes three stations and the price is $3,868,988.


1:3:6 concrete
B
Waterproofing 2-1/2" layers of asphalt mastic
B
3" min.
13' minimum clearance
C.L. Track
C.L. of subway
C.L. of track
2'
7'
6'-6"
6'-6"
31'
7'
2'
Top of rail
15"
9"
Concreted track
Section A-A
5'-6"
5'-6"
A
A
Sectional Plan
5'-6"
Section B-B

TYPICAL CROSS-SECTION OF SUBWAY


Fairmont St.
Ridge
Contract 301
St.
St.
St.
New Line
Spring Garden St.
N. 17th
Broad St.
N. 11th
N. 8th
St.
Vine St.
Reading R.R.
Existing Lines
BROAD ST. STA.
Arch St.
READING TERMINAL
City Hall
Market St.
Contract 302
Chestnut St.

LOCATION OF CONTRACTS 301 AND 302

South of the intersection of Ninth and Vine Sts., Ridge Ave. is 100 ft. wide between house lines and the subway work will be in the open. After completion, the street will be refilled to grade and roadway and sidewalk laid. Northward the width between house lines is 60 ft., roadway 34 ft. with two car tracks between Callowhill and Broad Sts. and a single line between Ninth and Callowhill, with poles and overhead construction. There are also numerous underground structures. This portion will be decked. Underpinning of building fronts is necessary from Ninth to Broad.

At Noble St. a steel structure carrying four tracks of the Reading Co. crosses over Ridge Ave. The contractor must temporarily support and protect this structure and provide permanent supports by substituting for four of the existing columns long steel columns extending to the bottom of the subway excavation, and by underpinning three other column footings.

Concurrently with the subway construction the steel pipe and electrical conduits and fittings to be embedded in the concrete for permanent lighting will be installed under another contract.

Included in the work is the construction of an underground conduit system for city transit cables along the line of the subway, and additional underground conduits for electrical bureau cables. Excavated material may be disposed of at River Road, north of Penrose Ferry Road, and will be spread and compacted by the bureau of highways.

On p. 1038 are listed the unit prices of principal items of the five bidders: (A) J. & R. Lombardi, 715 Real Estate Trust Bldg. (contract); (B) Golder Construction Co., 1600 Arch St.; (C) Silas Mason Co., 52 Vanderbilt Ave., New York; (D) Keystone State Corporation, 300 Philadelphia Bank Bldg.; (E) Henry W. Horst Co., 1505 Race St.

	A	B	C	D	E
Extra cost of supporting and protecting tracks of Reading Co. (lump sum)	$50,000.00	$19,000.00	$75,000.00	$40,000.00	$20,000.00
Reconstruction of Vine-Darien St. sewer (lump sum)	114,000.00	127,000.00	265,000.00	230,000.00	200,000.00
Maintenance of flow in Callowhill St. sewer crossing (lump sum)	20,000.00	10,000.00	25,000.00	12,000.00	20,000.00
Subway Excavation:					
210,000 cu.yd. north of station 305+02.5	7.00	7.00	5.00	6.30	8.00
39,000 cu.yd. south of station 305+02.5	5.00	4.00	5.00	3.00	8.00
12,000 cu.yd. excavation for pipes, sewers, conduits, etc.	4.00	5.00	11.50	3.00	8.00
1,500 cu.yd. removing pavement, excavating, and grading	4.00	4.00	10.00	3.50	8.00
100 cu.yd. pit excavation	30.00	35.00	40.00	50.00	25.00
Underpinning and Protecting Buildings North of Station 305+02.5					
5,300 ft. of front building 5 stories or less	45.00	55.00	40.00	60.00	42.00
100 ft. of front buildings, over 5 and less than 10 storeis	45.00	80.00	150.00	150.00	70.00
100 ft. of front buildings 10 stories or over	45.00	10.00	10.00	150.00	80.00
50 cu.yd. additional masonry for underpinning	40.00	45.00	35.00	50.00	25.00
Concrete Masonry:					
41,000 cu.yd. 1:2:4	16.00	18.00	17.70	16.50	18.00
4,000 cu.yd. 1:3:6	14.00	13.50	15.00	14.50	17.00
Granolithic Finish					
7,000 sq.yd. without abrasive wearing surface	1.00	1.00	2.00	1.50	.90
1,600 sq.yd. with abrasive wearing surface	1.50	1.35	2.50	2.00	1.20
22,000 sq.yd. rubbing surface of concrete	.50	.70	1.25	.25	1.50
1,000 cu.yd. brick masonry	35.00	35.00	35.00	35.00	35.00
2,000 sq.yd. vitrified shale brick sewer lining	4.00	4.50	5.00	5.00	7.00
100 cu.yd. rubble stone masonry in mortar	11.00	11.00	16.00	11.00	12.00
100 cu.yd. dry rubble masonry	7.00	7.00	15.00	7.00	8.00
250 sq.yd. granite block sewer lining	6.00	6.00	6.00	6.00	8.50
200 cu.yd. broken stone or pebbles for drains	4.00	4.00	3.50	5.00	4.00
Flagstones:					
500 sq.ft. 5-in. thick	1.50	.50	1.25	1.50	1.00
100 sq.ft. 6-in. thick	1.50	.70	1.50	2.00	1.50
Vitrified Clay Pipe:					
4,000 lin.ft. 4-in.	.35	.50	.50	.50	.50
1,000 lin.ft. 5 or 6-in.	.50	.60	.60	.70	.70
250 lin.ft. 5 or 6-in. channel pipe	.50	.50	.50	.80	.70
250 lin.ft. 8 or 10-in.	.80	.80	.75	.80	1.10
200 lin.ft. 12-in.	1.40	1.10	1.00	2.00	2.00
7,000 lin.ft. 15-in.	2.00	2.20	2.50	3.00	3.70
400 lin.ft. 18-in. channel pipe	2.00	2.00	2.50	4.00	2.20
5,000 lin.ft. 24-in. channel pipe	4.00	5.00	2.50	5.50	4.00
Extra Heavy Cast-Iron Soil Pipe:					
1,000 lin.ft. 2-in.	.60	.40	.75	.50	.70
4,500 lin.ft. 4-in.	1.00	1.00	1.00	1.00	1.20
3,100 lin.ft. 6-in.	1.50	1.50	1.75	1.50	1.80
New Inlets:					
2 No. 1	175.00	200.00	225.00	250.00	240.00
60 No. 2	200.00	180.00	200.00	250.00	240.00
2 No. 3	150.00	200.00	175.00	225.00	240.00
Taking Out and Rebuilding Inlets:					
22,000 sq.yd. asphalt mastic waterproofing	2.20	2.00	2.50	1.80	1.30
Fabric Waterproofing:					
200 sq.yd. 1-ply	.50	.95	1.00	1.25	.70
1,000 sq.yd. 2-ply	1.00	1.50	1.50	1.65	1.40
6,300 sq.yd. 3-ply	1.50	2.00	2.00	2.20	2.10
100 sq.yd. 4-ply	1.80	2.10	2.50	2.60	2.80
100 sq.yd. 1-ply dry roofing felt	.50	.20	1.00	.50	.50
100 cu.yd. brick in waterproofing compound	50.00	50.00	45.00	75.00	44.00
15,000 lb. riveted structural steel	.06	.06	.08	.04	.055
5,700,000 lb. structural steel beams and shapes	.045	.042	.056	.04	.055
Steel Ventilation Gratings:					
4,500 sq.ft. 2½-in. in depth, with frames	2.00	2.40	2.50	3.00	2.20
20,000 lb. miscellaneous steel, ladders, stairs, etc.	.13	.15	.20	.20	.15
117,000 lb. miscellaneous bolts	.07	.10	.06	.12	.10
7,000 lb. steel wire lath and anchors	.12	.15	.10	.25	.25
1,800,000 lb. deformed steel reinforcing rods	.04	.04	.045	.045	0.45
100 net ton interlocking steel sheetpiling	100.00	67.00	90.00	60.00	100.00
100 ver. ft. steel pipe piles	7.00	5.00	7.00	8.00	8.00
200 ver. ft. steel pipe piles	9.00	8.00	8.00	10.00	9.00
3,000 lb. w.i. pipe, except for electrical conduits, any size, with fittings	.10	.15	.15	.15	.12
6,000 lb. 3½-in. wrought-iron pipe for electrical conduits	.13	.15	.17	.20	.12
500 lb. steel pipe, except for water mains, any size with fittings	.10	.15	.20	.15	.15
2 emergency exit doors	400.00	500.00	600.00	700.00	450.00
65,000 lb. cast-iron frames and covers for manholes	.05	.07	.10	.10	.05
8,500 lb. miscellaneous iron castings	.07	.08	.12	.10	.10
100 M.ft. pine lumber in place	60.00	50.00	100.00	75.00	100.00
Cast-Iron Pipe, Furnished, Any Standard Size:					
220 net ton bell and spigot straight	45.00	42.00	60.00	75.00	60.00
25 net ton bell and spigot specials	125.00	140.00	175.00	200.00	150.00
25 net ton universal high pressure, straight	75.00	80.00	75.00	125.00	70.00
10 net ton universal high pressure, specials	175.00	200.00	200.00	200.00	170.00
Furnishing and Setting Bell End Water Gate Valves:					
20 4-in.	21.00	22.00	20.00	25.00	30.00
40 6-in.	30.00	36.00	40.00	40.00	40.00
30 8-in.	51.00	52.00	50.00	75.00	60.00
1 10-in.	76.00	80.00	70.00	90.00	100.00
6 12-in.	98.00	98.00	80.00	125.00	125.00
1 16-in.	170.00	165.00	150.00	250.00	250.00
1 20-in.	280.00	285.00	260.00	500.00	440.00
1 25-in.	500.00	505.00	500.00	750.00	700.00
300,000 duct ft. 3½-in. vitrified clay ducts	.30	.22	.235	.25	.25
1,000 duct ft. 3½-in. fiber ducts	.30	.26	.60	.30	.25
2,000 duct ft. concrete ducts	.50	.40	.50	.50	.25
1,000 lin.ft. 3-in. creosoted wood conduit	.35	.45	1.00	.50	.25
Furnishing and Laying Pavement:					
500 sq.yd. sheet asphalt	2.00	2.25	3.00	2.50	3.50
200 sq.yd. smooth dressed granite block	4.50	5.40	6.00	7.00	6.50
100 sq.yd. vitrified block	2.20	2.50	3.00	4.50	6.00
100 sq.yd. wood block	3.30	3.50	8.00	6.00	6.50
100 sq.yd. temporary brick sidewalk paving	1.50	1.80	2.25	2.00	2.50
Temporary Granite Block Paving, Gravel Joints:					
25,000 sq.yd. for furnishing and laying new granite blocks	6.00	5.00	5.00	5.50	4.50
1,000 sq.yd. for relaying old granite blocks	.60	.90	.70	1.50	1.00
Furnishing and Setting Curb:					
500 lin.ft. 6-in. straight granite curb	2.50	3.00	3.00	3.50	3.50
6,000 lin.ft. 8-in. straight granite curb	3.00	3.40	3.50	3.50	4.50
50 lin.ft. 6-in. curved granite curb	3.50	3.75	4.00	4.00	4.50
1,000 lin.ft. 8-in. curved granite curb	4.00	4.00	4.50	5.00	5.50
100 lin.ft. 8-in. steel edge concrete curb	1.25	1.50	2.00	3.00	5.00
500 lin.ft. resetting curb	1.00	.85	1.00	1.00	1.00
Sidewalk Paving:					
15,000 sq.yd. new granolithic	2.00	2.00	2.50	2.00	3.00
100 sq.ft. vault lights	3.00	3.00	5.00	3.50	3.00
1,700 sq.ft. safety treads	2.50	2.30	2.50	4.50	2.00
Aggregates of bids	$3,868,988	$3,892,368	$3,896,540	$3,898,890	$4,496,385